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Plant Selection. Those who are following the work of plant improvement locally will find interest in articles in this issue, one dealing with the selection of rice in Java, the other describing a dwarf coconut which is reported to have arisen as a mutation.

The New Leafhopper Enemy. The new leafhopper enemy, *Cyrtorhinus mundulus,* has been found to be very numerous in one locality at Olaa plantation. This is of particular interest in view of earlier reports of the rather discouraging way in which the insect has failed to multiply as had been expected. At Ewa plantation it was thought to be held in check by the kissing bug, which, according to Mr. Muir, is not so plentiful in the area at Olaa where the new leafhopper enemy is thriving.

Mr. Pemberton reports from Queensland that he has found another species of *Cyrtorhinus* which has habits apparently identical to the one which has been brought to Hawaii. If experiments now under way fully establish the fact that it is entirely a beneficial insect, an effort will be made to colonize it here.

Experiments with Potash. Distinct gains were obtained from potash applications in Onomea. No response whatever was obtained from phosphoric acid at the same place. It appears that 62 pounds of potash (125 pounds of sulphate of potash) can be applied with distinct profit, and that the economic limit may lie somewhat beyond this amount.

A test at Hamakua Mill Company showed some increase in yield from potash applications. All of the plots received some potash, so the results are not as clear cut as we would like. The laboratory results in this case do not show a particularly low potash content, and offer an exception to the correlations we have frequently noted between soil analysis and crop response.

In an experiment at McBryde we failed to get better yields from applications of phosphoric acid or potash in addition to the ordinary nitrogen fertilization. These results confirm those obtained two years ago in the same locality.

Wireworm Injury and Its Control. The chances of obtaining a natural enemy of the wireworm, which is doing damage at Hamakua, are materially strengthened by news from Dr. F. X. Williams, at Los Banos, P. I., that he has found a parasite on another and smaller species of wireworm than the one occurring here.

Fertilizer—How to Apply. A field test at Waipio gave yields that were essentially the same whether the fertilizer was divided into two, three, or four applications. The differences under the several treatments were hardly more than a ton of cane, notwithstanding the fact that the yields ran in the neighborhood of 110 tons of cane per acre. The cane was H 109, 24 months old. There were twelve repetitions of each treatment.

Results of the same character were also obtained in varying the proportion of fertilizer between the first and second season. The differences in cane weights were unimportant regardless of whether fertilizer was divided half in half between the two seasons, or one-fourth the first season and three-fourths the second season, or the reverse of this—that is, three-fourths the first season and one-fourth the second. Greater variation was found in the sugar than in cane yields, but Mr. Verret feels that these differences are due more to difficulties in sampling and to varying intervals of time between burning and sampling at the mill, rather than to the fertilizer treatments themselves.

The Sugar Cane Leafhopper and Its Parasites in Hawaii.*

By F. Muir.

The Leafhopper.

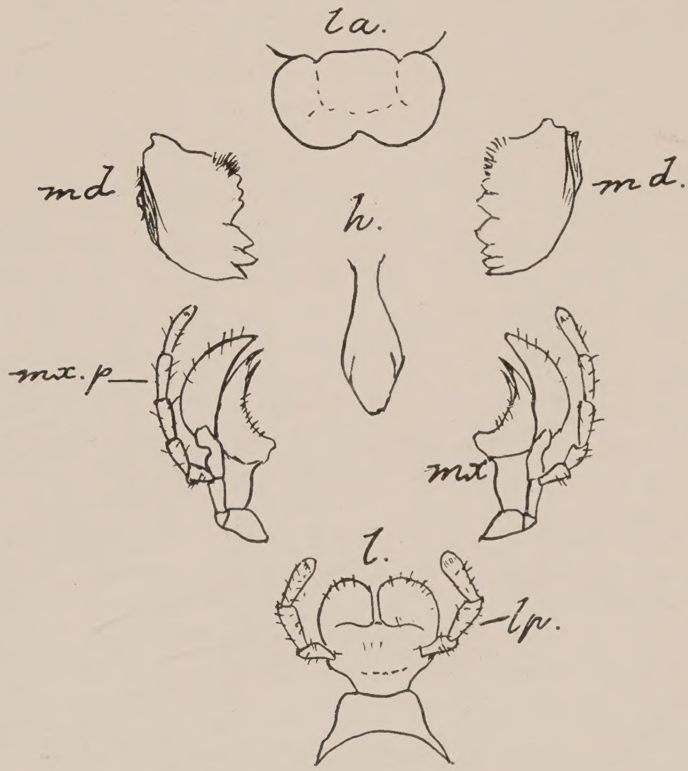
Most plantation men are well acquainted with the sugar cane leafhopper as it appears in the field, and many are acquainted with the damage it can do. Those whose memories go back to 1903–4–5 know the conditions that the plantations had to face before any effective control of the hopper had been found. But there are many men on plantations today whose personal knowledge does not go back so far, and conditions over the greater part of the islands are such that the leafhopper does not force itself upon their notice. To such these remarks are mainly addressed.

The sugar cane leafhopper belongs to the Order Hemiptera. The chief features of all the insects in this Order are the shape and arrangement of the

* A lecture delivered at the University of Hawaii in the Short Course for Plantation Men, October, 1920.

mouth parts and their method of functioning. Upon these also depend the nature of the damage done by the leafhopper.

In an ordinary mandibular or masticating insect, such as a cockroach, or grasshopper, there are six external organs situated around the oral opening or mouth (Fig. 1).



Mouth parts of a masticating insect.

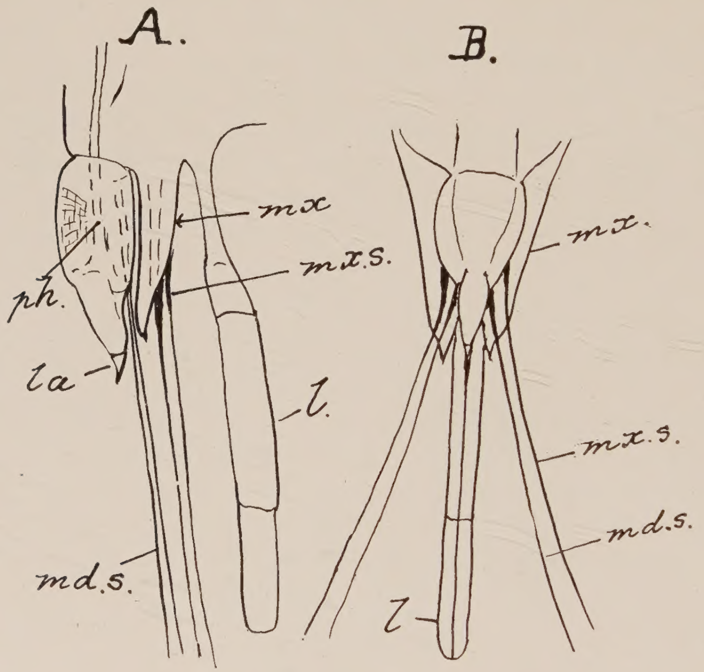
First there is the upper lip or labrum (la) which closes the mouth above; this consists of a flap without any appendages. Below there is a lower lip or labium (l) which is a complex organ and generally consists of two or three parts and bears a pair of jointed appendages, the labial palpi (lp) ; this closes the mouth below. On each side of the upper lip there is a strong mandible or gnawing organ (md) ; these are worked laterally by strong muscles and serve to cut and masticate the food. Between these mandibles and the lower lip is a pair of maxillae (mx) ; these are complex organs formed of several parts and carry a jointed palpus (mx.p.) and serve to hold the food and pass it into the mouth. Inside the mouth there is a small tongue or hypopharynx (h).

Grasshoppers, crickets, roaches, beetles, and the caterpillars of butterflies all have mouth parts of this type and they bite and chew their food. The nature of the damage done by this type is seen in the destruction of the leaf by army worms and the rose beetles, and of the stalk of the sugar cane by the sugar cane beetle borers.

Wasps have a slight modification of this type and bees a still greater modi-

fication, the tongue being often greatly developed for lapping. Flies have still greater modifications, some for piercing and sucking, such as a mosquito, and others for sucking, as in the house fly.

In the Hemiptera, to which the sugar cane leafhopper belongs, the modification is very great, although the parts found in the mandibular type are all present (Fig. 2). The labrum or upper lip (la) is small. The lower lip or



(A) Side and (B) front views of mouth parts of a leafhopper.

labium (l) is long, jointed, and deeply grooved down the middle of the upper surface, the edges of the groove meeting together thus forming a tube. Each mandible consists of a long, slender seta (md.s.) and each maxilla is formed of a plate (mx) and a long, slender seta (mx.s.). If viewed under a high-power microscope these four setae are seen to be fitted with a beautifully adapted tongue and groove along the greater part of their length. By this means they all fit together and form a complete slender tube, the four parts of which can move independently in a longitudinal direction without destroying the tube. The tips of the setae are sharp and the tips of the mandibles are barbed so that they are able to "saw" into the tissues of the cane plant, even into the hard rind. The labium forms a cover for the setae when at rest, and as a guide as the setae are driven into the plant; its tip also serves as a sense organ to understand the nature of the surface it is about to pierce. Just inside the mouth is the pharynx (ph) or entrance to the throat. This is formed of two plates curved up at the sides where they are attached to the wall of the head. Posteriorly the pharynx continues as the gullet into the stomach; anteriorly the upper plate of the pharynx joins the inner wall of the labrum and the lower plate joins the base of the tongue. Muscles are attached to the upper plate of the pharynx and the wall of the head, and by their contraction the upper plate moves away from the lower, thus causing

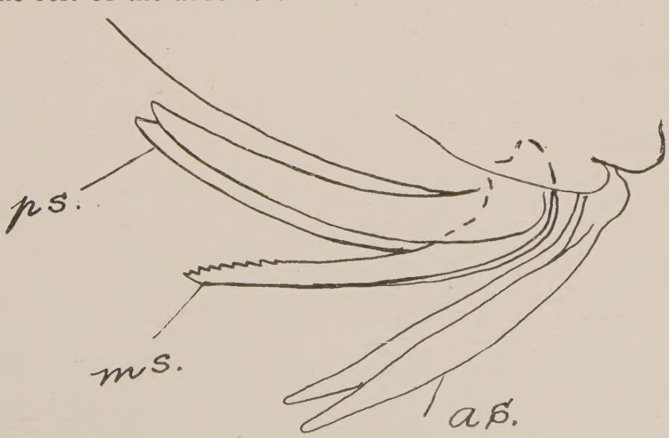
a vacuum, and a suction pump is thus formed. By this means the juices of the plant cells, in which lies the tip of the tube formed by the setae, are sucked up into the pharynx and swallowed, like ice cream soda through a straw.

We thus see that the leafhopper is incapable of biting the leaf or stalk of the cane, but can only make minute punctures through which they drain away the juices of the plant. The amount of juice that passes through the intestines of a leafhopper is very great. This may be necessary to enable them to get enough nutriment out of such a liquid food. The juices pass out of the anus as small, round globules on to a small appendage beneath the anus and is flicked off by the movement of this appendage and falls on the leaves.

In Trinidad it has been estimated that the froghopper on the sugar cane extracts and voids one-half drachm of clear liquid in one hour. Estimating fifty froghoppers to a stool and eight hours at night as their feeding time, would make about one and quarter pints of sap extracted every twenty-four hours. Our leafhopper is much smaller in bulk but more numerous, and when very numerous their extraction is likely to be higher than that. There is no indication that the leafhopper conveys diseases to the cane or injects toxin into the plant, as is probable with the froghopper of Trinidad.

The liquid extracted is called "honey dew." It spreads over the leaves and gives them a sticky surface over which a black fungus soon grows. It is this blackening of the leaves which often gives the first indication that hoppers are numerous in a field, and when found dried up on older leaves indicates that hoppers have been numerous in the field at an earlier date. This blackening of the upper surface of the leaves cannot be considered as harmful in itself, or looked upon as a cause of the stunting or death of the cane.

The two sexes of the insect can easily be recognized by an examination of the underside of the abdomen. In the female there is a brown, slender organ proceeding from near the base of the abdomen to the pointed apex. This is the ovipositor or egg-laying organ. In the male there is no such organ and the apex of the abdomen is not pointed but cut off straight, and the end forms a harder ring than the rest of the abdomen.



Ovipositor of leafhopper.

If we examine the ovipositor (Fig. 3) we find that it is made up of five separate pieces, two pairs and a single piece. The posterior pair (ps) is larger

than the others, slightly concave on the inner surface and forms a cover for the others. The middle organ (ms) is originally formed from a pair joined together along their posterior edge, thus forming a deep groove along their anterior surface; this organ is the active portion of the ovipositor, is harder, pointed at its apex, and toothed like a saw for some distance along its apical posterior surface. The anterior pair (as) is fastened by a tongue and groove process to the median organ so that they work as one organ and form a channel along which the egg passes into the cut made by the ovipositor.

By the aid of this organ the insect cuts into the tissue of the plant, either in the midrib of the cane leaf, which is its favorite locality, or into the thinner blade of the leaf or into the stalk of the cane. Into the hole thus cut it passes from one to seven eggs, or even more. The tops of the eggs project slightly beyond the hole and are covered with wax secreted by the female. This wax forms a protection against moisture even if it does not protect them from parasites. The small, white masses show up against the green leaf and stalk.

The wounds made by the egg punctures do not appear to do much injury to the cane. It is possible that they may give entrance to fungus spores, but this appears to be quite a minor cause of damage.

A female is estimated to lay about 75 to 100 eggs. These take from fifteen to forty days to hatch out, according to the temperature, an increase shortening the time and a decrease lengthening it.

The young upon hatching are like the adults in the arrangement of their mouth parts and their method of feeding, but they possess no wings or ovipositor, and have only two joints to their feet instead of three. They feed and grow larger and cast their skin four times before they become adults; the wing pads increase in size at each moult.

There are two forms of the adult, the long wing form in which the front wings reach considerably beyond the body, the hind wings are large and the insect is capable of flight; and the short wing form in which the front wings do not reach beyond the end of the body, the hind wings are absent or very small and the insect is incapable of flight. The short winged forms are found only, or mainly, during the cooler months of the year.

The time occupied in development from birth to adult varies with the temperature, but runs from around twenty to seventy days. The length of adult life in a state of nature is difficult to estimate, but is somewhere around sixty days.

The insect becomes active about dusk or just after sunset, when they rise on the wing and move about. Mating takes place at night.

The species of leafhopper we have in Hawaii *(Perkinsiella saccharicida)* is found in Java and Australia, but has not yet been found in any of the intervening islands. If it be a native of both of these localities we should expect to find it in some of these islands, but if it has been introduced into Australia with sugar cane from Java it is quite likely not to exist in them. It is found in Formosa, where it may have been introduced from Hawaii or Java with cane cuttings. I took one specimen in Fiji, where it may have been introduced from Australia or Hawaii. Hawaii received it from Australia in cane cuttings some eighteen or nineteen years ago.

At present twenty-three species of the genus are known, with the following distribution:

1. *P. saccharicida*—Java, Australia, Federated Malay States, Formosa, Hawaii, Fiji (one specimen).
2. *P. vastatrix*—Java, West Borneo, Amboina, Ceram, Papua, Philippines, Federated Malay States, (East Africa?)
3. *P. graminicida*—Australia.
4. *P. vitiensis*—Fiji, Savage Island or Niue.
5. *P. papuensis*—Papua.
6. *P. bicoloris*—Papua.
7. *P. lalokensis*—Papua.
8. *P. amboinensis*—Amboina.
9. *P. variegata*—Papua.
10. *P. rattlei*—Papua.
11. *P. pallidula*—Borneo.
12. *P. manilae*—Philippine Islands.
13. *P. fuscipennis*—Philippine Islands.
14. *P. lineata*—Philippine Islands.
15. *P. saccharivora*—Philippine Islands.
16. *P. pseudosinensis*—Philippine Islands.
17. *P. manilae*—Philippine Islands.
18. *P. bakeri*—Philippine Islands.
19. *P. sinensis*—China, West Borneo, Japan.
20. *P. thompsoni*—Guam, Java.
21. *P. insignis*—India.
22. *P. facilis*—India.
23. Species unidentified, near *P. bakeri*—West Africa.

We thus see that it is scattered over the whole of the tropical old world, but it is not found in the new world.

Leafhopper Parasites.[1]

There are a number of methods employed to combat insect pests. For the sake of convenience they are generally divided into two classes, artificial and natural.

Under artificial are included such methods as insecticides, repellants, traps, baits, catchers and protectors. Others which are generally spoken of as artificial, but which might well be called natural, are resistant varieties of the host, change or rotation of crop, and agricultural methods such as clean culture, late or early planting. Under natural methods are included all natural enemies such as animals and plants. But the artificial introduction of an enemy from one region to another might well be included under artificial. The division does not bear criticism, but it is convenient and generally understood.

When the leafhopper was first recognized as a serious pest to the sugar industry in Hawaii considerable discussion ensued as to which method would be best to employ, and various artificial methods were tried. But it soon became

[1] I use this term in a general sense to include all natural enemies.

evident that owing to local conditions and the nature of the crop, no artificial method then known would adequately cope with the situation.

This decision having been reached, Messrs. Koebele and Perkins proceeded to Fiji and Australia to study the leafhopper in those countries with the object of introducing such parasites as they found doing effective work on *Perkinsiella*. The result of their work was the introduction of several parasites, which were so successful that in a short period after their introduction the whole problem was changed. On over ninety per cent of the cane area of the islands the leafhopper was controlled to such an extent that no practical damage was done; over the remaining ten per cent of the area the leafhopper was but partially controlled so that local outbreaks occurred, causing more or less damage.

Since then the genus *Perkinsiella* has been studied in various countries bordering the Pacific, and a close study made of the various factors keeping the different species in check. It has been shown by this study that similar factors are at work in all of these localities, and it is due to them that no loss occurs in such sugar growing countries as Fiji, Australia, Java, Philippines and Formosa.

Efforts have been made to introduce into Hawaii still more of the factors working in these regions, but owing to certain biological conditions this has so far only been partially successful.

In each of the areas in which *Perkinsiella* has been studied it has been found that a certain number of primary insect parasites preyed upon the leafhopper; a number of other secondary parasites affected it indirectly by attacking the primaries; tertiary parasites sometimes attack the secondaries. The problem is again complicated by some of the primaries attacking one another. Fungus parasites sometimes attack the central host and also the secondaries and tertiaries. Mongoose, rats, birds, lizards, and frogs also play their part in this association, which is known as the biological complex for the insect studied. Even such a biological complex is not independent, but works in the orbits of other biological complexes. The same species may pertain to two or more complexes, and as their food increases or decreases in one complex, so will their effect upon the others alter.

The interaction of the species forming a complex, and of the various complexes which make up a fauna of a given area are difficult to follow. They are affected by the seasons and the weather conditions.

The reason why we have had such quick and pronounced success in Hawaii with some of our introduced parasites is because of the limited nature of our native fauna and flora, which consequently makes our associations of complexes much more simple than is generally found in continental areas. But our individual complexes are not always so simple as is believed, and the biological complex drawn up for *Perkinsiella saccharicida* in the Hawaiian islands, although incomplete, shows forty-one insects which act and interact upon one another to the advantage or disadvantage of the central host.

Complexes have been drawn up for insect pests in various parts of the world, and deductions have been made from them. In certain cases the complexity of the association has been brought forward as a reason against the introduction of parasites. It is maintained that the introduction of a single parasite into such a complex problem can have very little effect upon the ultimate results.

This conclusion is fallacious. We are not confined to introducing only one parasite if we can find more; and a single introduced parasite may entirely alter the whole complex so far as the status of the central host is concerned. In the case of the *Perkinsiella* complex in Hawaii *Paranagrus* forms the keystone of the whole problem. Withdraw that factor and the whole of the remainder as they stand today would not be able to hold the leafhopper in check.

The list below shows that the *Perkinsiella* complex is as complicated as that of the froghopper in Trinidad, which has been cited as a case where introduced parasites could not succeed.

Those who insist that parasitic work is only feasible in small, oceanic islands, entirely overlook the great *Vedalia* classic. This little ladybug was successfully introduced into California to check *Iceria purchasi;* later it was introduced into Portugal, Egypt, Capetown, New Orleans, and elsewhere with equal success. These are all rich continental areas.

By a greater knowledge of biological complexes in the future it is possible that we may be able to attack a pest not directly by introducing primary parasites, but by reducing some of the secondary.

List of Primary, Secondary, and Tertiary Parasites.

Diagram I.

1. *Paranagrus obtablis* Perks.

This is a minute wasp of the family Mymaridae. It lays its eggs in the eggs of the leafhopper, upon the contents of which the grub feeds. It undergoes its metamorphosis within the eggshell of the host, eventually emerging as a mature insect through a small hole which it gnaws. As the length of the life cycle of *Paranagrus* is about four weeks, and that of *Perkinsiella* about ten, the parasite can have two and a half generations to one of the host. This makes it a very efficient parasite if other factors are not favorable. As will be seen below it is affected by both the *Ootetrastichus* and *Cyrtorhinus,* and it is attacked by Lacewings, *Xiphidium* and Earwigs. Being such a minute, delicate insect it is affected by weather conditions, especially by rains. In spite of all these it is by far the most important of the parasites on *Perkinsiella* and without it all the rest of them could not hold the hopper in check under present conditions. We can call it the keystone parasite.

This insect was introduced from Australia by Koebele and Perkins in 1905.

2. *Anagrus frequens* Perk.

This insect is similar to *Paranagrus* in its life cycle, and is closely related to it. It is not nearly so numerous and does not play such an important part in the complex. It was introduced from Australia by Koebele and Perkins.

3. *Ootetrastichus beatus* Perk.
4. *Ootetrastichus formosana* Timb.

These two species of parasitic wasps are larger than the two mentioned above and their size brings about a somewhat different habit. After having devoured the contents of one egg, which is not sufficient food to carry the larva to maturity, it attacks the other eggs in the cluster and devours them all. It

PARASITE COMPLEX OF PERKINSIELLA SACCHARICIDA IN HAWAII.

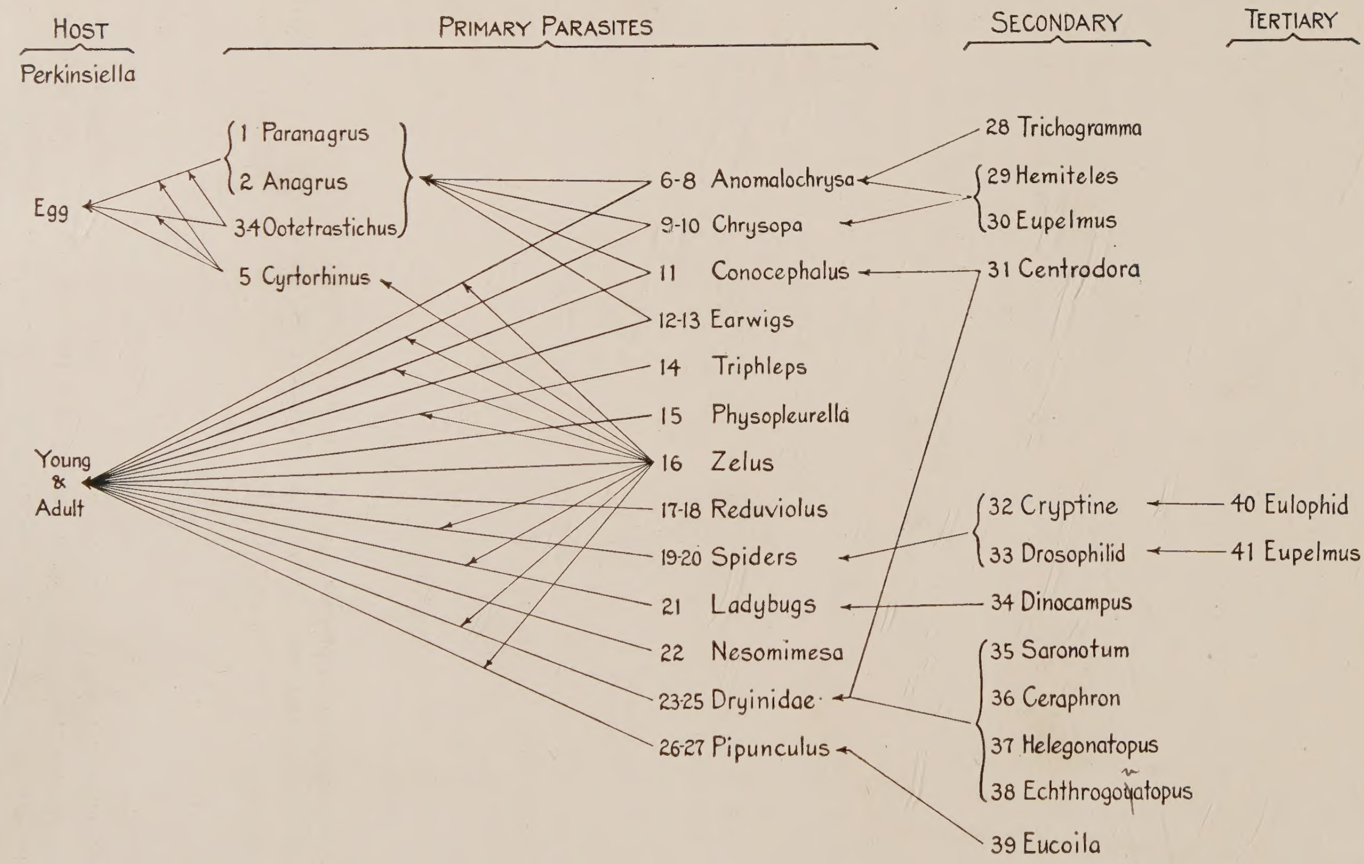


DIAGRAM I.

then turns to a pupa within the egg cavity and the adult eventually gnaws a round hole through which it passes to the open. It takes about six weeks for its life cycle. As it attacks hoppers' eggs which have been parasitized by *Paranagrus* and *Anagrus* as well as those which have not been parasitized, its effect upon these two parasites must be considered. *O. beatus* Perk. was introduced from Fiji by Koebele, and *O. formosana* from Formosa. It was hoped that the latter, coming from a cooler locality than the former, might work better in some of the higher lands.

5. *Cyrtorhinus mundulus* (Bred.).

This insect belongs to the same Order as the leafhopper, the Hemiptera, and its mouth parts are built on the same plan and function in the same way. Instead of feeding upon the juices of plants, as the leafhopper does, it appears to confine itself to the contents of the leafhoppers' eggs, which it pierces with its slender setae and sucks.

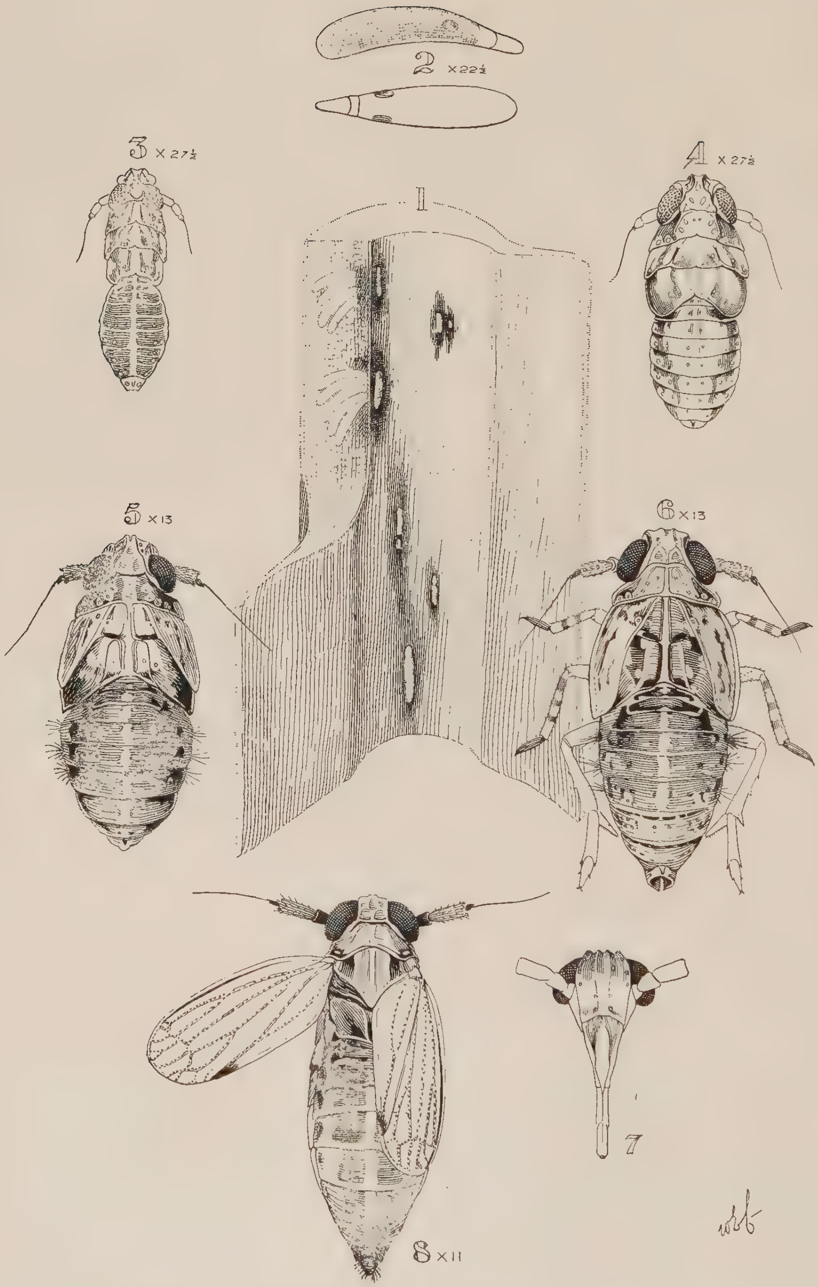
It was introduced from Australia and Fiji, in which countries it plays a very important role in the complex. It is hoped that it will play a similar part in Hawaii in those localities where climatic conditions are not most favorable for *Paranagrus*. It is established in certain localities in Oahu and Hawaii, but it has not increased or spread in a satisfactory manner. Observations indicate that some factors are keeping it down. So far we have only found *Zelus* attacking it, but as the young of *Zelus* and *Cyrtorhinus* congregate together in the same localities on the sugar cane and the former prey upon the latter, and are often numerous, it is possible that *Zelus* is the chief or only limiting factor.

Zelus has no parasites in Hawaii and it would be an interesting experiment to introduce some from California if they can be found.

Lacewings.

6. *Anomalochrysa deceptor* Perk.
7. *A. raphidioides* Perk.
8. *A. gayi* Perk.
9. *Chrysopa microphya* McLachl.
10. *Chrysopa* op.

These five neuropteroid insects belong to the Lacewinged flies. Their larvae are predacious and feed chiefly upon plant-lice, but other small insects, including young hoppers, do not come amiss to them. The mandibles are sickle-shape and grooved. They grasp their victim with these mandibles and suck them dry. The larvae of the *Anomalochrysa* run over the cane leaves without protection, but the *Chrysopa* covers itself with foreign matter, including the skins of its victims. They take such small fry as *Anagrus* and *Paranagrus* and so counteract their direct attack upon the young hopper to some extent. *Anomalochrysa* and *Chrysopa microphya* are native insects, but the other species of *Chrysopa* is a comparatively recent immigrant, which has not yet been identified. These are parasitized by three small wasps: *Trichogramma* sp. (28) on the eggs and *Hemiteles tenellus* (29) and *Eupelmus* sp. (30) on the cocoons.



(1) Section of cane leaf showing egg punctures and eggs. (2) Eggs greatly magnified, the dark mark being the eyes of the developing embryo. (3) First stage of nymph or young. (4) Second stage ditto. (5) Third stage ditto. (6) Fourth stage ditto. (7) Face of same. (8) Adult short winged female.

11. *Conocephalus saltator* (Sauss.).

This large "longhorned grasshopper" is abundant in pasture lands, grass along roads, and in cane fields when not kept clear of weeds and grasses. Both young and old devour young and adult hoppers and they play an important part in the hopper complex. The young *Conocephalus,* and even the adults, devour the egg parasites (1–4) and from that point of view partly counterbalance their direct attacks on the hopper. But the sum of their work appears to be beneficial and their presence should be encouraged in the cane fields. A parasite attacks their eggs (*Centrodora xiphidii* No. 31) and *Zelus* and spiders also take their toll.

This is a native of Central America and found its way into the islands some thirty years ago. It is described and figures under the name of *Xiphidium varipenne* in Bulletin I, part 7.

Earwigs.

12. *Anisolabis annulipes.*

13. *Chelisoches morio.*

There are several earwigs found in our cane fields, but the above mentioned two are the most common and of greatest economic importance.

They feed upon both young and adult leafhoppers and so are of economic importance in keeping down their numbers. But *Chelisoches morio* has been shown to destroy a great number of egg parasites, and so it counterbalances the good it does. I have seen *Zelus* attacking them at times.

These are both foreign insects which have become established in our Islands.

Hemiptera.

14. *Triphleps persequens.*

15. *Physopleurella mundulus.*

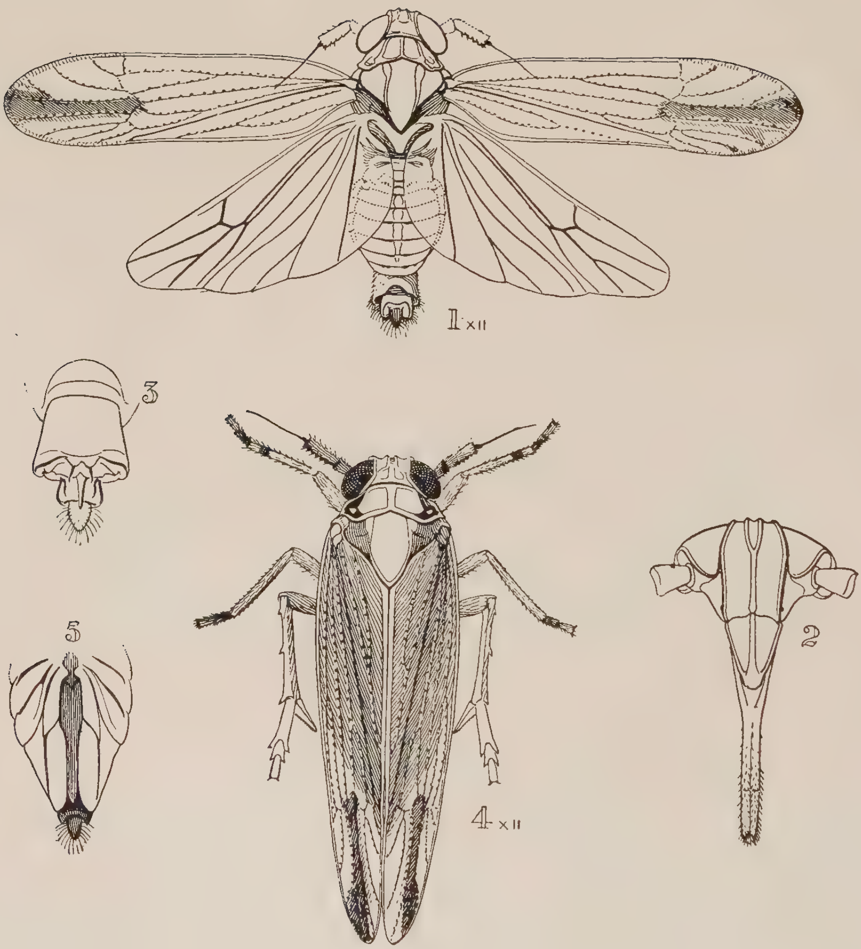
16. *Zelus renardii.*

17. *Reduviolus blackburni.*

18. *Reduviolus capsiformis.*

These five insects all belong to the same order as the sugar cane leafhopper and *Cyrtorhinus*, the Hemiptera, and have the mouth parts constructed upon the same plan and functioning in a similar manner. They are predacious and feed upon the leafhopper.

Zelus renardii is by far the most abundant and important economically and plays a conspicuous part in the leafhopper complex, for not only does it attack the leafhopper in the adult and young stages, but it attacks most of the other direct enemies. Taken altogether its effect upon the cane is considered as being more harmful than beneficial. It is considered the chief factor in checking the increase and spread of *Cyrtorhinus;* it has a decided effect upon the number of ladybugs in the cane fields and is an enemy of *Chrysopa*. It is a Californian insect that found its way into the island some twenty-five to thirty years ago. It has spread all over the islands and is very numerous in cane fields, especially where leafhoppers are abundant. It has been figured and described under the name of *Zelus peregrinus* in Entomological Bulletin No. 1, part 7.



(1) Adult male. (2) Face of same. (3) Apex of abdomen of same. (4) Adult long winged female. (5) Ventral view of abdomen of female showing ovipositor.

Spiders.

19. *Pagiopalus atomarius.*
20. *Tetragnatha mandibulata.*

Some twenty species of spiders are found in the cane fields, but only two can be considered as economically important. *Pagiopalus* is one of the hunting spiders and does not build a web, and is the more important of the two. Their presence in cane fields where leafhoppers are numerous is generally made evident by their egg cases attached to the cane leaf, as many as fifty having been counted on a single leaf. That they prey upon other insects of the complex is true, but their result I consider as beneficial.

There are several parasites on the spiders in Hawaii. Several species of hunting wasp, a Cryptine wasp (32) and a fly (33). The cryptine wasp is parasitized by an Eulophid (40) and the fly (Drophilidae) by an *Eupelmus* (41). The spiders found in our cane fields are figured and described in Entomological Circular No. 7.

Ladybugs.

21. *Coelophora inaequalis.*

There are several ladybugs in the cane fields, but only one that plays much part in the leafhopper complex. This is figured and described under the name of *Coccinella repanda* in Entomological Bulletin No. 1, part 7. It feeds upon Aphis and leafhoppers, more especially on young hoppers. It is preyed upon by a wasp (*Dinocampus terminatus* 34), and is attacked in both the larvae and adult stages by *Zelus.*

Hunting Wasps.

22. *Nesomimesa hawaiiensis.*

This wasp burrows into the soil and makes a number of little chambers which she stocks with leafhoppers, and therein places her eggs. It has a very restricted range. It is fully described and figured in The Record for September, 1918, page 175. It plays but a minor part in the complex.

This is a native insect which has transferred its attention from native hoppers to *Perkinsiella.*

Dryinidae.

23. *Echthrodelphax fairchildii.*
24. *Haplogonatopus vitiensis.*
25. *Pseudogonatopus hospes.*

The females of these ant-like wasps are often wingless and then they look even more ant-like than the winged forms. Their front legs are developed into pinchers somewhat like a crab's. By the means of these pincher-like claws they catch and hold the leafhopper while they lay an egg in it. The young parasite comes out and attaches itself to its host and develops, the old skins remaining on and looking like a small dark sack. By the time the parasite is full fed the young hopper is sucked dry and dies.

These parasites are preyed upon by five other parasites, *Centrodora xiphidii* (31), that also attacks the eggs of *Xiphidium; Serenotum americanum* (35), *Cerephron abnormis* (36), *Helegonatopus pseudophanes* (37), and *Ethro-*

gonatopus sp.(38). Of these *S. americanum* is by far the most effective in keeping down the Dryinidae. In fact were it not for these secondary parasites I belive that these Dryinidae would be so effective that we should have no trouble whatever with leafhopper. Here is an instance where to relieve a parasite of its enemy might do more good than introducing a new parasite.

Echthrodelphax was first described from these islands and may be a native insect, or it may be an immigrant from some place at present unknown; the other two species were introduced, one from Fiji and the other from China.

26. *Pipunculus juvator.*

27. *Pipunculus hawaiiensis.*

These are two native flies which have taken to attacking the same leafhopper. Their habits are fully described and one figured in The Record for September, 1918, page 189. They search for the hoppers, which they pounce upon and carry into the air, holding them by means of their large claws. By the means of a sharp ovipositor an egg is laid in the body of the hopper and then the hopper is released. The parasite develops inside the host at the expense of the juices of the hopper, and when it is fully grown the hopper is killed and the parasite emerges to pupate.

Even in the interior of the body of the hopper this fly grub is not concealed from its enemies, for a small wasp *(Eucoila* sp. 39) manages to parasitize it.

Ants.

Pheidole megacephala is abundant in most of the cane fields and has a decided effect upon all insect life found there. If included in the diagram it would have to be indicated as attacking nearly every insect mentioned, as there is little that it will not take if it has the opportunity.

Fungus.

Metarrhizium anisopliae.
Entomophthora sp.
Sporotrichium sp.
Cordyceps.

The green mascardine fungus *(Metarrhizium anisoplioe)* is common on many insects in the islands, especially on beetles, and plays a part in the complex. But it is the other three species that are the more important, as they are all directly parasitic on the leafhopper. In certain areas in certain seasons, when the conditions are favorable, one or more of these become very common, and at times appear to wipe out the leafhopper over an area. For this reason they play an important direct part in the complex. At times when its infestation is very great it is possible that it may eventually lead to an increase of hoppers. If a severe epidemic carries off all the adults and young hoppers, leaving only the eggs (some of which will be parasitized and some not), then no more eggs will be laid till the young hatch out and grow to maturity, a period of some forty to fifty days. During a period of about three or four weeks the egg parasites will hatch out, but finding no eggs to oviposit in will die, thus leaving the next generation comparatively free from egg parasites. This may appear far fetched and theoretical, but observations indicate that such a thing may occur and probably does at times.

Vertebrate Enemies.

Mongoose, rats, lizards, frogs, and birds all play a part within the complex. Mynahs are the most numerous of the birds in our cane fields and take a toll of most of the larger insects found there, *Concocephalus* being an appreciated food.

Mynahs are preyed upon by both rats and mongoose, and the mongoose also preys upon the rats as well as lizards and frogs. Lizards and frogs are scarce in our cane fields, and so play but a small part in the complex.

Weather.

Affecting all the above mentioned factors is the weather. Increase of heat shortens the life cycle of most of the insects and decrease lengthens it. As all the insects are not affected proportionately, this leads to an alteration in the complex.

Rains are inimical to such delicate parasites as *Paranagrus* and *Anagrus* (the former being the most important parasite in the complex), and so they play a most important part in the complex. Moisture is an important factor in the development of fungus and thus plays an important part. Prevailing winds will gradually drift hoppers in one direction, and should they be drifted into sheltered fields, are liable to accumulate there and breed, thus being constant spots for leafhopper outbreaks.

Thus we see that the biological complex that has gathered around *Perkinsiella saccharicida* since it arrived in the islands some nineteen years ago is as great as is known to be round insects in their own habitats in continental areas. The greater the individual complex, the greater the difficulty may be in introducing and establishing an efficient insect parasite. But this does not make the task impossible. A more important point in this work is often the interplay between the different individual complexes that make up the fauna of a region.

The Effect of Cush Cush on Clarification.

By H. F. Bomonti and Will R. McAllep.

Developments in milling work have resulted in finer grinding of the cane, and this has been accompanied by an increase in the amount of cush cush that passes the mill screens and finds its way into the mixed juice. This is particularly true where shredders are used. The object of this investigation was to determine the effect of this cush cush that remains in the mixed juice on the increase in purity that can be obtained during clarification.

It was pointed out in the 1920 Annual Synopsis of Mill Data: "This year, however, the press cake per 100 cane has increased from 2.32 to 2.62 per cent, a very considerable increase. * * * There seems, however, to be some connection between the increased amount of press cake and the smaller increase in purity compared with last year. Twelve out of eighteen factories reporting a larger amount of press cake, report a smaller increase in purity compared with last year, while eleven out of nineteen factories reporting less press cake, report a greater increase in purity."

H. S. Walker, in a contribution to the Report of the Committee on Manufacture of Sugar and Utilization of By-Products, H. S. P. A., 1920, says: "It seems very probable that the action of heat and lime may extract from the bagacillo gums and other substances which are not conducive to the best results in the boiling house." Mr. S. S. Peck, in the same report, states: "It was found when fine trash was present during the clarifications, there was a very decided increase in the amount of soluble gums present, over tests where this was removed, and the less the acidity, the greater was the solvent action."

This is a subject which has apparently received but little attention, for no published references to it other than the above were found.

The following preliminary experiments were made:

A portion of mixed juice from H 109 cane from Oahu Sugar Company was limed with 6 cc. milk of lime per liter, brought to a boil and allowed to settle on a steam bath for an hour and a half. A second portion was passed through a 100-mesh screen, removing all but the finest of the suspended matter. Both portions were then filtered with kieselguhr and through hardened filter paper and analyzed.

The results are given in Table 1.

TABLE 1.

	Reaction (Equivalent to % CaO)	Purity		Effect of Cush Cush
		Screened Juice	Unscreened Juice	
Before Clarification ...	0.011 acid	80.62		
After Clarification	0.008 alk.	82.44	82.04	0.40

Mixed juice from H 109 cane from Honolulu Plantation Company was next tried. From one portion all suspended matter was removed by filtration through kieselguhr and hardened filter paper. Portions of both the unfiltered and filtered juices were then limed with 1, 3, 5 and 7 cc. milk of lime and treated as before. The results follow:

TABLE 2.

	Filtered		Unfiltered		Effect of Cush Cush
	Reaction	Purity	Reaction	Purity	
Mixed juice ..	0.006 acid	88.49	0.006 acid	87.11	
1 cc lime	0.002 alk.	89.46	0.002 alk.	88.53	0.93
3 cc lime	0.010 alk.	89.03	0.012 alk.	88.57	0.46
5 cc lime	0.014 alk.	90.16	0.016 alk.	89.56	0.60
7 cc lime	0.018 alk.	90.70	0.018 alk.	89.75	0.95

A similar series of Lahaina juice from Honolulu Plantation Company gave results agreeing closely with the above.

The above results indicate that the presence of cush cush diminishes the increase in purity that can be obtained in clarification.

These preliminary experiments bring up the following points for further investigation:

First: The cause of the irregularities in the differences shown above.

Second: Whether the filtration through kieselguhr influenced the results.

Third: Whether the differences will increase with increasing amounts of cush cush in the juice.

Fourth: Whether the differences are due to the action of lime and heat on the finely divided material or o the presence of lower purity juice in the cush cush.

With respect to the first point, polarization was determined by Horne's dry lead method. When sucrose determinations were made, Walker's inversion method was used. With reasonable precautions these methods are sufficiently accurate so that unavoidable errors have but slight effect on the purity coefficient. Brix determinations, however, were made with a hydrometer and readings accurate to more than 0.05 degrees can hardly be expected. Most of the juices worked with were between 11 and 14 brix. An error of 0.05 in the brix determination affects the purity of such juice to the extent of some 0.4 degrees; almost a half of the maximum difference noted above. When juices are filtered the brix can be determined with a much greater degree of accuracy with a pycnometer, so in order to more accurately estimate the comparatively small differences in purity found, the brix of all filtered juice in the work subsequent to that reported in Table 3 was made with this instrument.

The clarified juices were filtered with kieselguhr, because the differences in purity with which we are dealing are comparatively small. Kieselghur filtrations completely removes suspended solids and makes practicable a considerably greater degree of accuracy in analyses than would otherwise be the case.

In mixed juice, we have found that it gives apparent increases in purity of

from 0.4 to 1.4, the difference being due to the effect of the suspended solids and colloidal matter on the brix of the unfiltered juice. An example of this is shown in Table 2, where the increase in purity is 1.38.

In well settled clarified juice the difference is much smaller and rarely amounts to 0.2. Kieselghur does not remove solids from solution, and as the check samples and those to which cush cush was added were both filtered with it; this treatment should not influence the comparisons made in this investigation. That this is the case may be seen by an inspection of Table 5. One series in this experiment was filtered through filter paper and a corresponding series with kieselghur. The juices filtered with kieselghur were limpid. Those filtered through filter paper were slightly turbid and of a lighter tint. While the former are slightly higher in purity, averaging 0.12, the figures for the effect of the cush cush are in both cases practically identical.

Several experiments were made to determine whether the effect of cush cush on the purity was in proportion to the amount of cush cush added.

In a sample of mixed puice from H 109 cane from Honolulu Plantation Company the greater part of the cush cush was removed by passing the juice through a 100 mesh screen. The juice was then limed to a suitable point and to liter portions of this juice, weighed amounts of the cush cush were added. This cush cush had been subjected to a pressure of about 1000 lbs. per sq. in., reducing it to a moisture content of about 60%. The juices were then boiled, allowed to settle for an hour and a half on a steam bath, filtered with kieselghur and analyzed. The reaction of the juice is expressed as equivalent to per cent CaO, referred to litmus as an indicator.

The results follow:

TABLE 3.

Treatment	Reaction = % CaO	Gravity Purity	Effect of Cush Cush
Untreated	0.008 acid	84.66	
6 cc. lime	0.012 alk.	87.78	
6 cc. lime + 10 gm. cush cush....	0.012 alk.	86.67	1.11
6 cc. lime + 20 gm. cush cush....	0.012 alk.	86.98	0.80
6 cc. lime + 25 gm. cush cush....	0.012 alk.	85.95	1.83
6 cc. lime + 30 gm. cush cush....	0.012 alk.	86.73	1.05

In the above experiment a very much smaller increase in purity was obtained in samples containing cush cush than was obtained in the check. No definite relation is shown between the differences in purity and the amount of cush cush present. This is not necessarily conclusive, however, as the brix determinations were made with a hydrometer and, as already noted, were subject to a comparatively large factor of error.

Juice from Lahaina cane from Honolulu Plantation Company was next treated. The general procedure was the same as the proceeding experiment, but in addition three series were run at different alkalinities. Brix determinations were made with a pycnometer. The results appear in Table 4.

TABLE 4.

Treatment	Reaction	Purity	Effect of Cush Cush
Untreated	0.006 acid	88.40	
2 cc. of lime	0.002 alk.	88.46	
2 cc. lime + 25 gm. cush cush....	0.002 alk.	87.99	0.47
2 cc. lime + 50 gm. cush cush....	0.002 alk.	88.02	0.44
4 cc. of lime	0.006 alk.	88.93	
4 cc. lime + 25 gm. cush cush....	0.006 alk.	88.67	0.26
4 cc. lime + 50 gm. cush cush....	0.006 alk.	88.05	0.88
5 cc of lime	0.010 alk.	89.83	
5 cc. lime + 25 gm. cush cush....	0.010 alk.	89.54	0.29
5 cc. lime + 50 gm. cush cush....	0.010 alk.	89.07	0.76

The differences due to the presence of cush cush are smaller in Table 4 than in Table 3. They show, however, a fairly consistent tendency to increase with increasing amounts of cush cush and with higher alkalinities.

The figures given in Table 5 are also for Lahaina cane from Honolulu Plantation Company. A comparison of the filtration of the clarified juice through kieselghur with filtration through filter paper, previously referred to, also appears in this table.

TABLE 5.

	Reaction	Filtration Through Filter Paper		Kieselguhr Filtration	
		Purity	Effect of Cush Cush	Purity	Effect of Cush Cush
Untreated juice	....	86.56	...	....	...
6 cc. lime	0.010 alk.	88.55	...	88.68	...
6 cc. lime + 10 gm. cush cush...	0.010 alk.	88.40	0.15	88.54	0.14
6 cc. lime + 25 gm. cush cush...	0.010 alk.	88.05	0.50	88.14	0.54
6 cc. lime + 50 gm. cush cush...	0.010 alk.	87.55	1.00	87.67	1.01

In the following series the question of to what extent the influence of the residual juice in the cush cush was responsible for the effect of the latter on the purity was also studied. To this end part of the cush cush was pressed to remove the surplus juice, as in the above experiments. A second portion was extracted by alternately soaking and pressing six times in a similar manner to determining fiber in cane.

The following is a typical analysis of the untreated and extracted cush cush:

	Untreated	Extracted
Fiber	22.0	27.4
Moisture	70.0	72.4
Polarization	6.2	0.09
Solids not polarization (by difference)	1.8	0.11
Residual juice purity (calculated)	77.5	45.5

Details of the following experiments were the same as the above, except that to portions of the limed juice equal weights of extracted and unextracted cush cush were added.

Data from an experiment with Lahaina juice from Honolulu Plantation are given in Table 6.

TABLE 6.

	Reaction	Unextracted Cush Cush		Extracted Cush Cush	
		Purity	Effect of Cush Cush	Purity	Effect of Cush Cush
Screened mixed juice	....	89.30	...	....	...
6 cc. lime	0.010 alk.	90.33	...	....	...
6 cc. lime + 10 gm. cush cush	0.010 "	90.14	0.19	90.18	0.15
6 cc. lime + 25 gm. cush cush	0.010 "	89.72	0.61	89.64	0.69
6 cc. lime + 40 gm. cush cush	0.010 "	89.49	0.84	89.50	0.83

Table 7 contains data from a similar experiment on H 109 cane from Oahu Sugar Company.

TABLE 7.

	Unextracted Cush Cush		Extracted Cush Cush	
	Purity	Effect of Cush Cush	Purity	Effect of Cush Cush
Screened mixed juice	80.62	...	....	...
6 cc. lime	82.43	...	....	...
6 cc. lime + 25 grams cush cush	81.56	0.87	81.52	0.91
6 cc. lime + 50 grams cush cush	81.19	1.24	81.20	1.23

All of these data confirm the indications of the preliminary experiments. In every case when juice has been limed and cush cush added to one portion, the purity of the clarified juice resulting from this portion has been lower than that of the portion to which no cush cush has been added.

The results shown in Tables 4 to 7 inclusive, the analyses in which have a greater degree of accuracy than those in the tables preceding, because the brix

was determined with a pycnometer, clearly indicate that the effect due to the cush cush increases with increasing amounts.

Data given in Tables 6 and 7 show that the effect of the cush cush is not on account of the residual juice contained in it, for cush cush practically free from such juice causes fully as great a decrease in purity as cush cush which has not been extracted.

The following is quoted from Bulletin No. 91 of the Louisiana Experiment Station by C. A. Browne and R. A. Blouin.

"A study of the hydrolytic products obtained by digesting purified bagasse with caustic soda showed cane fiber to be an exceedingly complex substance."

"The following results, calculated to 100 parts of cane fiber (protein, ash, fats, etc., excluded), give the approximate percentage of the different hydrolytic products":

Cellulose (including oxy-cellulose)........	55%
Xylan	20
Arabin	4
Lignin	15
Acetic acid	6

"The cellulose obtained from the sugar resembles that obtained from corn stalks in many of its properties. The pith cellulose is very easily attacked by concentrated alkalies, and for this reason great care must be exercised in making paper stock from bagasse."

"The Pentosans, xylan and arabin, constitute the cane gums. These constituents of the fiber are easily soluble in alkalies, from which they are precipitated by alcohol as a gummy deposit. . . . . . ."

"The Lignin is obtained from cane fiber by digesting with solutions of the alkalies, to which it imparts a yellowish brown coloration."

"Acetic acid, the well known acid of vinegar, may be obtained from cane fiber by digesting with caustic alkali and then distilling with a slight excess of sulphuric acid.

"The above substances do not exist in cane fiber as a mechanical mixture, but in a state of most intimate combination, forming a very complex molecule whose exact structure is not yet understood."

In the process of paper making the finely divided material is digested with alkali to attack and render soluble part of the constituents other than cellulose. Though in making paper a fairly strong alkali is used, while in clarification of cane juice the concentration of alkali is small, nevertheless in the latter case somewhat similar reactions with the cush cush may be expected.

The following work was done to investigate this reaction under conditions somewhat approximating those existing during clarification:

The soluble matter was removed from a quantity of cush cush by thoroughly extracting with water, the excess of water removed in a press and the material dried in a thin layer in the sun. The final moisture content was 14.6%.

Analyzed by Cross & Bevan's method, this material was of the following composition, calculated to a moisture free basis:

Cellulose	56.6
Inorganic*	3.5
Non-cellulose	39.9

* Carbonate ash from which the carbon dioxide has been subtracted.

It will be noted that the cellulose content of this sample corresponds closely with that of the quoted analysis of extracted bagasse.

Of this cush cush 11.7 grams, corresponding to 10 grams of moisture free material, were added to a liter of water containing enough lime to approximate the conditions in the above clarification experiments. The mixture was boiled, digested on a steam bath for an hour and a half, and filtered. After washing with cold water and drying, it was found that 9% of the cush cush had been dissolved.

Analyzed by Cross & Bevan's method, this residue was found to have the following composition:

Cellulose	66.0%
Inorganic	3.5
Non-cellulose	30.5

This analysis shows that most of the loss in weight was due to removal of the non-cellulose.

By assuming that the material that went into solution in the above experiment was added to juice of a given composition, we can calculate what the effect would be on the purity, and so have a similar basis for comparing this with the other experiments.

Ten grams of cush cush added to the juice in the preceding experiments corresponds to adding 0.3 to 0.4% suspended solids. This is probably not far from the average amount of suspended solids in mixed juice in Hawaiian factories, and we will make the comparison on a basis of this amount. In these experiments summarized in Tables 4, 5, 6 and 7, the minimum depression of the purity per 10 grams of cush cush was 0.15, the maximum 0.35, and the average 0.22.

In the experiment when the cush cush was digested with lime water the amount present was equivalent to 1.0% suspended solids, so the result must be divided by three to bring it to the above basis. Assuming, then, that one-third of the material dissolved was added to a juice of 12.0% solids, and 83.33 purity, the solids would be increased to 12.03%. The purity would then be 83.12, a decrease of 0.21%. Quantitatively, then, the last experiment is in fair agreement with the preceding experiments on juice; that is, the amount of cush cush that went into solution approximated the quantities that must have gone into solution in the juices to affect the purities to the extent noted.

It can then be stated that if cush cush is present when juice is limed and heated, a part of it goes into solution, adding to the impurities in the juice, with the result that the increase in purity secured during the clarification is less than it would have been had no cush cush been present.

From a chemical point of view, keeping the mixed juice as free from cush cush as possible is desirable; indeed, a more thorough screening of the juice than is the usual practice would probably be profitable. Some efforts have been made along this line and the problem does not appear insoluble. In this connection we would note that the fuel value of the recovered cush cush is a considerable item.

Heavy liming of the settlings, from the same point of view, is an objectionable practice, for the greater part of the cush cush that was in the mixed juice is concentrated in these settlings and conditions are favorable for dissolving further portions of it.

While it is true that, according to the indications of the above experiments,

the depression of the purity due to the average amount of cush cush found in the juice does not appear large, a constant effect of this kind results in a loss of considerable magnitude. Taking the figures for 1920 from the Annual Synopsis and assuming that the suspended solids in the mixed juice have depressed the syrup purity 0.2, as seems fairly probable from these experiments, we can calculate that if this depression had not taken place the yield would have been increased by 0.188%. This would have amounted to over 1000 tons of sugar on the 1920 crop.

A Bedding Machine of Cane Lands.

The device here illustrated, an Avery implement, is said by its manufacturers to have been in hard service all winter in Louisiana, and with gratifying results. The machine is designed, we are told,

> "to take an old piece of cane land that has been cultivated eight or ten years and in one operation transform it into a fine seed bed in which to plant new cane. There is a large coulter in front that splits the hills and the ridge. The first pair of disks throws out the ridge and starts the furrow, the next pair does it still more, and the last thing is a big middle buster that opens up the row. The cane can then be planted in the furrow thus made or the motor cultivator will make a new trench at the top of the ridge. Some plant it one way and some another. . . . . . ."

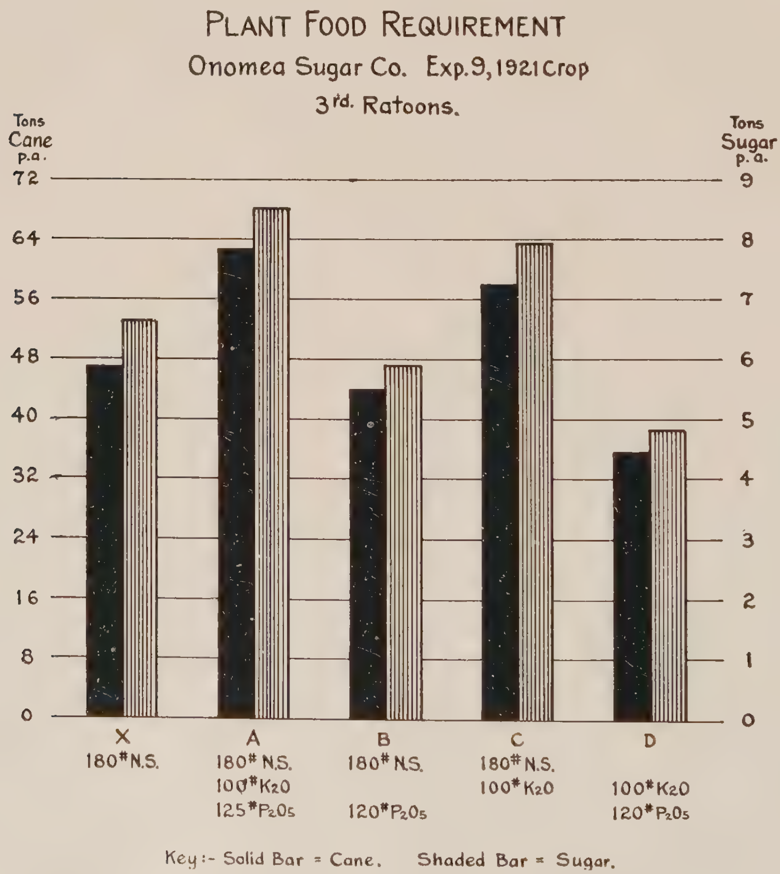
Similar implements, mostly of plantation construction, have been employed here and there in the Hilo district for destroying the heavy stools of Yellow Caledonia cane preparatory to planting operations.

Nitrogen, Phosphoric Acid and Potash in Different Combinations.

Onomea Sugar Company, Experiment No. 9, 1919 and 1921 Crop.

This was a test designed to determine the need for nitrogen, phosphoric acid, and potash by the soils of the Hilo coast.

The experiment was laid out in field No. 3 of the Onomea Sugar Company.



The cane was Yellow Caledonia, second and third ratoons. Two crops have now been harvested from these plots.

The following table gives the fertilizer applications in pounds per acre.

POUNDS OF FERTILIZER PER ACRE

Plots	1st Season		2nd Season		Total Pounds		
	1st Fert.	2nd Fert.	3rd Fert.	4th Fert.	Nitrogen	P_2O_5	K_2O
X	257 lbs. C I*......	257 lbs. C I*......	290 lbs. N. S.**	290 lbs. N. S.	180	0	0
A A A	257 lbs. C I*...... 364 lbs. Acid Phos. 103 lbs. Sul. Pot...	257 lbs. C I*...... 364 lbs. Acid Phos. 103 lbs. Sul. Pot...	290 lbs. N. S.	290 lbs. N. S.	180	120	100
B B	257 lbs. C I....... 364 lbs. Acid Phos.	257 lbs. C I....... 364 lbs. Acid Phos.	290 lbs. N. S.	290 lbs. N. S.	180	120	0
C C	257 lbs. C I....... 103 lbs. Sul. Pot...	257 lbs. C I....... 103 lbs. Sul. Pot...	290 lbs. N. S.	290 lbs. N. S.	180	0	100
D D	364 lbs. Acid Phos. 103 lbs. Sul. Pot...	364 lbs. Acid Phos. 103 lbs. Sul. Pot...	290 lbs. N. S.***	0	45 †	120	100

* C I = 17½% Nitrogen.
** N. S. = Nitrate of Soda, 15.5% N.
*** Applied to these plots by mistake.
† To 1919 crop only.

The sugar yields per acre for each treatment for the two crops were as follows:

Plots	Treatment	Tons of Sugar per Acre		
		1919 Crop	1921 Crop	Average
A	Nitrogen, Pros. Acid and Potash......	6.64	8.52	7.53
C	Nitrogen and Potash................	6.88	7.94	7.41
X	Nitrogen only	5.95	6.64	6.29
B	Nitrogen and Phos. Acid............	5.81	5.90	5.85
D	Phos. Acid and Potash, no Nitrogen..	6.09 *	4.84	5.46

The results obtained from the two crops harvested show the present need of these soils to be nitrogen and potash. Omitting phosphoric acid had very little effect on the yield (comparing A and C plots). On the other hand, omitting potash (B plots) lowered the yield by over a ton and a half of sugar per acre. The loss caused by leaving out nitrogen amounted to over two tons per acre.

An analysis of these soils showed a total acid soluble K_2O content of 0.184%, and .0048% citrate soluble P_2O_5. This is a very low potash content and such soils are expected to respond to potash applications; as was the case here. The

* These plots received 45 lbs. of nitrogen per acre by mistake. This accounts for the higher yield obtained in 1919.

Plant Food Requirement

Onomea Sugar Co. Exp. 9, 1921 Crop

3rd. Ratoons.

73 X 54.71	49 B 46.26	25 X Discarded	1 A 60.54
74 C 56.97	50 X 48.83	26 B 38.40	2 X 52.66
75 X 53.75	51 C 59.35	27 X 38.49	3 B 41.41
76 D 43.88	52 X 70.90	28 C 55.02	4 X 46.00
77 X 51.26	53 D 38.27	29 X 44.59	5 C 56.06
78 A 62.74	54 X 43.18	30 D 31.97	6 X 38.74
79 X 47.56	55 A 61.94	31 X 44.71	7 D 32.69
80 B 46.27	56 X 44.82	32 A 50.39	8 X 48.88
81 X 48.90	57 B 39.54	33 X 48.43	9 A 50.53
82 C 56.34	58 X 46.37	34 B 46.30	10 X 59.90
83 X 47.90	59 C 58.86	35 X 40.08	11 B 48.80
84 D 30.87	60 X 43.89	36 C 55.40	12 X 44.07
85 X 29.61	61 D 37.06	37 X 40.10	13 C 62.81
86 A 56.95	62 X Discarded	38 D 32.43	14 X 51.07
87 X 45.94	63 A 58.24	39 X 41.99	15 D 37.11
88 B Discarded	64 X 50.05	40 A 50.28	16 X 53.11
89 X Discarded	65 B 42.41	41 X 42.11	17 A 61.55
90 C Discarded	66 X 47.40	42 B 46.38	18 X 50.06
91 X Discarded	67 C 54.16	43 X 47.64	19 B 47.62
92 D 34.02	68 X 45.66	44 C 61.12	20 X 53.65
93 X 45.29	69 D 25.63	45 X 51.91	21 C 61.69
94 A 58.05	70 X 43.05	46 D 45.95	22 X 64.44
95 X 47.84	71 A 54.12	47 X 51.06	23 D 39.53
96 B 42.44	72 X 45.65	48 A Discarded	24 X 51.49

Field Road

Summary of Results

Plot	No. of Plot	Treatment			Yields Per Acre			Gain or Loss Over Adjoining X Plots	
		Nitrogen	K_2O	P_2O_5	Cane	Q.R.	Sugar	Cane	Sugar
X	48	180	—	—	47.02	7.08	6.64		
A	12	180	100	120	62.53	7.34	8.52	+15.51	+1.88
B	12	180	—	120	44.08	7.47	5.90	− 2.94	− 0.74
C	12	180	100	—	57.98	7.30	7.94	+10.96	+1.30
D	12	—	100	120	35.78	7.39	4.84	−11.24	− 1.80

phosphoric acid is high and the field test gave no response from the use of this compound.

DETAILS OF EXPERIMENT.

Object:

To determine the plant food requirements of sugar cane on the soils of the Hilo district. The comparison is made between:

1. Nitrogen alone.
2. Nitrogen and phosphoric acid and potash.
3. Nitrogen and phosphoric acid.
4. Nitrogen and potash.
5. Phosphoric acid and potash.

NOTE: — This is a repetition of Onomea Experiment 9 (1919 Crop).

Location:

Onomea Sugar Company, Field 3, on field path leading to the Japanese Cemetery.

Crop:

Yellow Caledonia, third ratoons.

Layout:

Number of plots = 96.

Size of plots = 1/15 acre, consisting of 6 lines, each line 5.66′ wide and 85.4′ long. A two-foot space separates each plot. The front line of plots 1–24 is on the field path, although plot stakes are put in 4′ to prevent them from being knocked out.

Plan:

FERTILIZATION IN POUNDS PER ACRE OF NITROGEN, PHOSPHORIC ACID, AND POTASH.

Plot	No. of Plot	Sept. 15, 1919			Nov. 15, 1919			Jan. 15 1920	April 15 1920	Total		
		N. as C—1	P_2O_5	K_2O	N. as C—1	P_2O_5	K_2O	N. as N. S.	N. as N. S.	N.	P_2O_5	K_2O
X	48	45	0	0	45	0	0	45	45	180	0	0
A	12	45	60	50	45	60	50	45	45	180	120	100
B	12	45	60	0	45	60	0	45	45	180	120	0
C	12	45	0	50	45	0	50	45	45	180	0	100
D	12	0	60	50	0	60	50	0	0	0	120	100

C—1 = 17½% N. (8¾ sul. amn., 8¾ nitrate of soda).
P_2O_5 as acid phosphate (16.5% P_2O_5).
K_2O as sulphate of ammonia (48.68% K_2O).

Experiment planned in 1917 by L. D. Larsen and W. P. Alexander.
Experiment laid out in 1917 by W. P. Alexander.

J. A. V.

Liming at the First Mill.

Editor Hawaiian Planters' Record: — A recent number of the Louisiana Planter contained an article (reprinted in The Record for June, 1921), by Maurice Bird on "An Innovation in the Manner of Liming Cane Juice." The method of liming there described is identical (except in a few minor details) with the process worked out by a Mr. Ruggles of Cuba, and incorporated in the design for a sugar factory by Mr. O. B. Stillman, of New York and Cuba, in 1899 or 1900. This factory was constructed for the American Sugar Co. of Molokai, but was purchased by the McBryde Sugar Co. and erected on their plantation on Kauai in 1901. The system of applying all the lime required for clarification to the bagasse immediately on its issuance from the first mill was practiced in McBryde mill during the six years from 1901 to 1907 that I was connected with that company. I made a full report on the process, which was presented by the Machinery Committee to the Planters' Association meeting in 1903, and is probably available in one of the numbers of The Hawaiian Planters' Monthly for 1904. That report was rather enthusiastic, and although I did not overstate the advantages of the process, I overlooked (or had not then experienced) its disadvantages. For instance, the bagasse takes up, not only the lime required for clarifying, but a very large quantity which it retains through all the subsequent macerations and crushings in the manner that vegetable fibers "fix" mordants and dyes. The process thus requires (I quote from memory) over *three times* the quantity of lime that is required by the ordinary defecation process.

Mr. Ruggles' original intention was to produce a friable, non-fusible ash and so eliminate the destructive effect of the very fusible potash silicate ash on the arches, walls, and ash pits of the furnaces, in which forced draft was employed and the temperature intense. His process was not entirely successful in this direction (at any rate at McBryde), unless a very large excess of lime was added at the mills. This latter contingency he provided for by installing a sulphuring apparatus as part of his system.

Mr. Weinrich, of Cuba and New York, secured a patent in 1904 for a similar process, about which he and Mr. O. B. Stillman had a somewhat heated controversy in the pages of the International Sugar Journal of that year. Mr. Bird, therefore, has been anticipated by quite a few years, so far as the liming is concerned, but his addition of "a pint of formaldehyde twice a day" is distinctly novel. A quart of formalin in 200,000 gallons of juice would be a painfully small voice in a very vast wilderness.

Jas. W. Donald.

Kekaha, Kauai, Hawaii, July 6, 1921.

The Value of Potash in Hamakua.

HAMAKUA MILL COMPANY. OBSERVATION TEST B.

This test was intended, primarily, for purposes of observation, in order to obtain some idea of the potash requirements of Hamakua soils as quickly as possible.

The test was laid out in a plant field of Yellow Caledonia. This field was planted in May, 1919, and not cut back. The experiment was not started until February, 1920. It is possible that had the potash been applied earlier the response would have been greater. At the time of laying out the experiment, all the field had received five hundred pounds of high grade fertilizer per acre. This fertilizer contained eleven per cent nitrogen, six per cent phosphoric acid, and seven per cent potash. During the second season nitrate of soda was used uniformly on all the plots.

The amounts of potash used and the yields obtained are given in the following table:

TREATMENT	Lbs. Potash per Acre	Tons per Acre	
		Cane	Sugar
500 lbs. H. G.*	35	22.8	2.98
" 285 lbs. mol. ash **	130	24.9	3.33
" 570 lbs. "	230	23.8	3.28

* H. G. = 11% N., 6% P_2O_5, 7% K_2O.
** Molasses Ash = 33.5% K_2O.

Increasing the potash in this case from 35 to 130 pounds per acre increased the yield of sugar 0.35 ton per acre, or about 12%. Larger amounts of potash produced no further gains.

The soil in this case had a potash content of 0.44% total acid soluble K_2O. This has generally been regarded as fairly high.

Fields in other parts of the islands, notably at Waipio, with a lower potash content have shown no response to potash applications. This shows the difficulty of attempting to gage fertilizer requirements from soil analysis and shows the importance of field tests on the different soil types.

DETAILS OF EXPERIMENT.

Object:

To observe:

(1) The value of additional applications of potash.

(2) The amount of potash to apply.

Location:

Hamakua Mill Company, Field 18 J.

Crop:

Yellow Caledonia, plant cane (planted May, 1919).

Layout:

Number of plots = 19.

Size of plots = 1/10 acre, consisting of 6 lines, each line 4.83 feet wide and 150 feet long.

Plan:

Plots	No. of Plots	Plot Numbers	Lbs. K_2O per Acre	Lbs. Mol. Ash per Acre (33.68% K_2O)
X	7	1, 4, 7, 10, 13, 16, 19.................	0	0
A	6	2, 5, 8, 11, 14, 17...................	95	285
B	6	3, 6, 9, 12, 15, 18..................	195	570

Previous Fertilization:

Five hundred pounds per acre of High Grade (11% N., 6% P_2O_5, 7% K_2O), giving about 35 pounds of potash per acre.

Subsequent Fertilization:

Nitrate of soda only, uniformly to all plots; applied by the plantation.

J. A. V.

Where Greatest Attention Is Required in Power-Plants.*

Boilers differ in their operation from other power-plant equipment in that it is possible to operate all types of good design up to practically the same efficiency, irrespective of their size. With other power-plant equipment, with the possible exception of oil engines, the efficiency is fixed to a large degree by the size of the apparatus. In standard electric generators and motors the efficiency for small sizes ranges down to around sixty to seventy per cent, whereas in the larger sizes efficiency as high as ninety-eight per cent has been obtained. With large steam turbines operating on high-pressure high-temperature steam expanding down to low vacuum, their best water rate is down to between ten and eleven pounds per kilowatt-hour; with small units the water rate may be nearly double this. With reciprocating engines similar wide ranges in steam consumption are found, also considerable difference of efficiency in engines of the same size but of different types.

With boilers it is possible to obtain around eighty per cent efficiency with almost any type burning a fairly good grade of coal. There is, however, no other part of the station equipment in which there are so many factors under human control that influence the efficiency as with the boiler. When an electric generator has been properly designed and installed, its efficiency is practically fixed irrespective of what the attendants may do. If the machine is neglected, its service may be impaired, but its efficiency will remain the same under given load conditions. This is true of the turbine and steam engine, although not to

* From "Power."

the degree that it is for the electric generators. However, when the former are properly installed and put in condition to operate at their best water rates for given loads, they will continue to operate at these efficiencies for considerable periods, when expanding through a given range of pressure and temperature. Although conditions of the turbine blading, and valves and valve gears of reciprocating engines will influence efficiency, this in general becomes a serious factor only after considerable periods of service. But the efficiency of boilers is influenced by a number of factors immediately under the control of the operators—the amount of air, methods of firing, condition of boiler surfaces, both inside and out, temperature of feed water, etc.—all of which, if not given the continuous attention of the operator, may cause serious loss of efficiency. In addition the arrangement of baffling, proper heat insulation, not only of the exposed surface of the boiler but also of the settings, and the prevention of air leaks into the furnace may have a marked influence on efficiency. As a result, instead of boilers operating at an efficiency of around eighty, many are found operating at fifty or less.

Although much has been done during recent years in the development of apparatus to eliminate the human element in boiler operation, this part of the plant remains the one requiring the greatest attention. Furthermore, the evidence indicates that it is going to continue to require the greatest interest, and strange as it may seem, it is only at this late date that there is a realization that graduation of power-plant operators should be from the engine room to the boiler room, rather than from the boiler room to the engine room.

[W. E. S.]

Amounts of Nitrogen Applications.

WAILUKU EXPERIMENT No. 1 — 1917, 1919, AND 1921 CROPS.

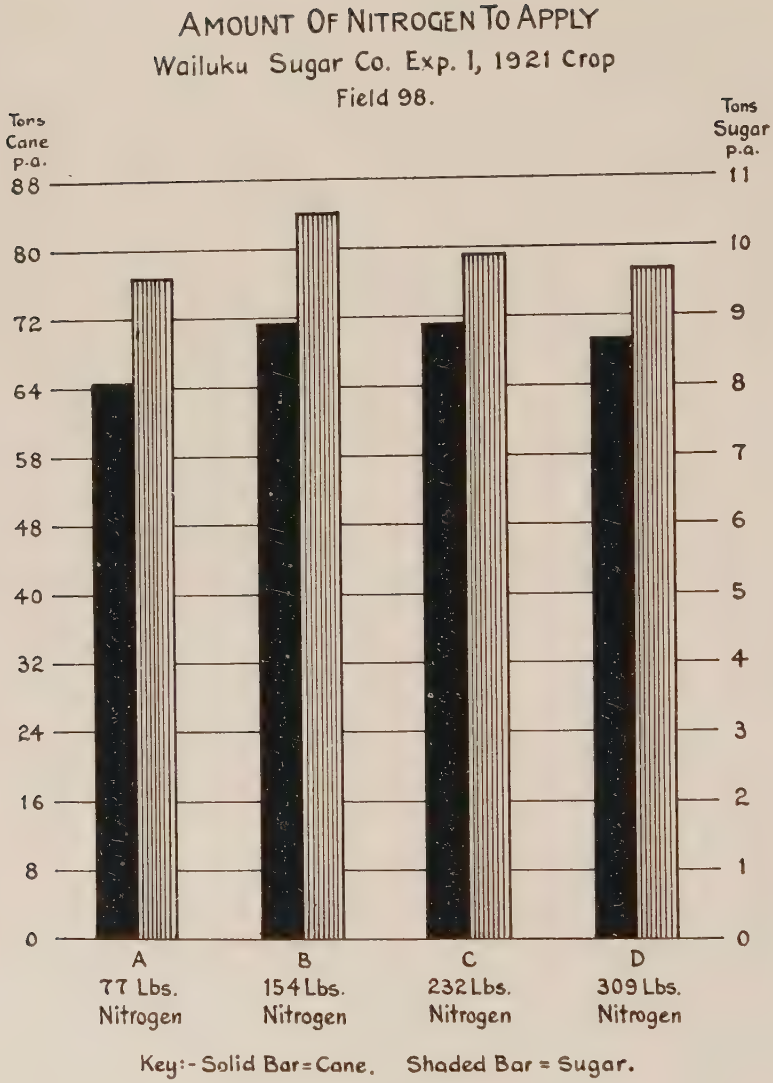
This was an experiment to determine the economic limit in nitrogen applications. The experimental cane was Lahaina. The first crop (1917) was plant, the other two, long ratoons. The test area was well irrigated and did not suffer from lack of water.

The amounts of nitrogen used varied from 77 to 309 pounds per acre, obtained from complete fertilizer and nitrate of soda. The amounts of fertilizer used and the yields obtained from each crop are given in the following table:

1917 CROP — PLANT.

No. of Plots	Treatment	Lbs. Nitrogen per Acre	Total per Acre	
			Cane	Sugar
36	900 lbs. C. F.* 200 lbs. N. S.	112	81.6	12.07
12	1200 lbs. " "	139	83.8	12.24
12	1500 lbs. " "	166	84.6	12.30
12	1800 lbs. " "	193	89.5	13.01

* C. F. = 9% N., 7% P_2O_5, 3½% K_2O.



1919 CROP — FIRST RATOON.

No. of Plots	Treatment				Lbs. Nitrogen per Acre	Total per Acre	
	Aug., '17 B 5*	Nov., '17 B 5*	Feb., '18 N. S.	May, '18 N. S.		Cane	Sugar
18	175 lbs.	175 lbs.	125 lbs.	125 lbs.	77	66.6	10.39
18	350 lbs.	350 lbs.	250 lbs.	250 lbs.	154	75.0	11.27
18	525 lbs.	525 lbs.	375 lbs.	375 lbs.	232	75.0	10.92
18	700 lbs.	700 lbs.	500 lbs.	500 lbs.	309	74.1	10.88

*B 5 = 11% N., 8% P_2O_5.

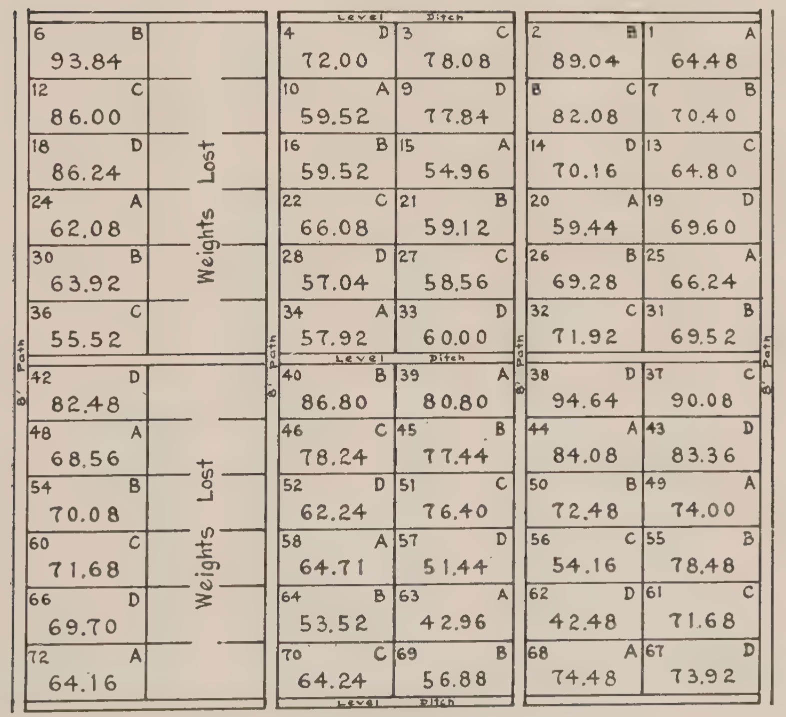
1921 CROP — SECOND RATOON.

No. of Plots	Treatment				Lbs. Nitrogen per Acre	Tons per Acre	
	Aug., '19 B 6 *	Nov., '19 B 6 *	Feb. '20 N. S.	Apr., '20 N. S.		Cane	Sugar
18	175 lbs.	175 lbs.	125 lbs.	125 lbs.	77	64.7	9.58
18	350 lbs.	350 lbs.	250 lbs.	250 lbs.	154	71.3	10.51
18	525 lbs.	525 lbs.	375 lbs.	375 lbs.	232	71.3	9.89
18	700 lbs.	700 lbs.	500 lbs.	500 lbs.	309	69.3	9.67

* B 6 = 11% N., 6% P_2O_5.

AMOUNT OF NITROGEN TO APPLY

Wailuku Sugar Co. Exp. 1, 1921 crop
Field 98.



Summary of Results

Plots	No. of Plots	Treatment	Yields Per Acre		
			Cane	Q.R.	Sugar
A	18	77 Pounds Nitrogen	64.75	6.76	9.58
B	18	154 Pounds Nitrogen	71.35	6.79	10.51
C	18	232 Pounds Nitrogen	71.30	7.21	9.89
D	18	309 Pounds Nitrogen	69.27	7.14	9.67

With the plant crop, harvested in 1917, profitable gains were obtained up to 193 pounds, say 200 pounds, per acre of nitrogen. With the two ratoon crops, the profitable limit dropped to 154 pounds of nitrogen per acre. Further additions of nitrogen produced no increase in cane and lowered the quality of juices, thereby decreasing the output of sugar.

DETAILS OF EXPERIMENT.

Fertilization: Amount to Apply, 1921 Crop.

Object:

To determine the most profitable amount of fertilizer to apply on Lahaina ratoons at Wailuku.

Location:

Wailuku Sugar Company, Field 98, Plots 1–72.

Crop:

Lahaina, second ratoons.

Layout:

Number of plots = 72.

Size of plots = 1/16 acre, consisting of 8 furrows, 4½ feet wide and 75½ feet long. Measurements taken from middle of water course to middle of water course. The plots are separated from each other by a blank furrow.

Plan:

FERTILIZATION, POUNDS PER ACRE.*

Plots	No. of Plots	Aug. 1, 1919	Nov. 1, 1919	Feb. 1, 1920	May 1, 1920	Total Lbs. Nitrogen
A	18	175 lbs. B-6	175 lbs. B-6	125 lbs. Nit.	125 lbs. Nit.	77
B	18	350 lbs. B-6	350 lbs. B-6	250 lbs. Nit.	250 lbs. Nit.	154
C	18	525 lbs. B-6	525 lbs. B-6	375 lbs. Nit.	375 lbs. Nit.	232
D	18	700 lbs. B-6	700 lbs. B-6	500 lbs. Nit.	500 lbs. Nit.	309

* B-6 = Regular Brewer & Co. fertilizer known as—

B-6 = 11% Nit. (4½% sul., 4½% nit., 2% organic), 6% Phos. Acid (3% bonemeal, 3% superphos.).

Nitrate of Soda = 15.5% Nitrogen.

NOTE: — With the plant crop one-half of the experiment received coral sand at the rate of 10 tons per acre.

Experiment originally planned by L. D. Larsen.

Experiment originally laid out by Messrs. Ayres and Gross of Wailuku Sugar Company.

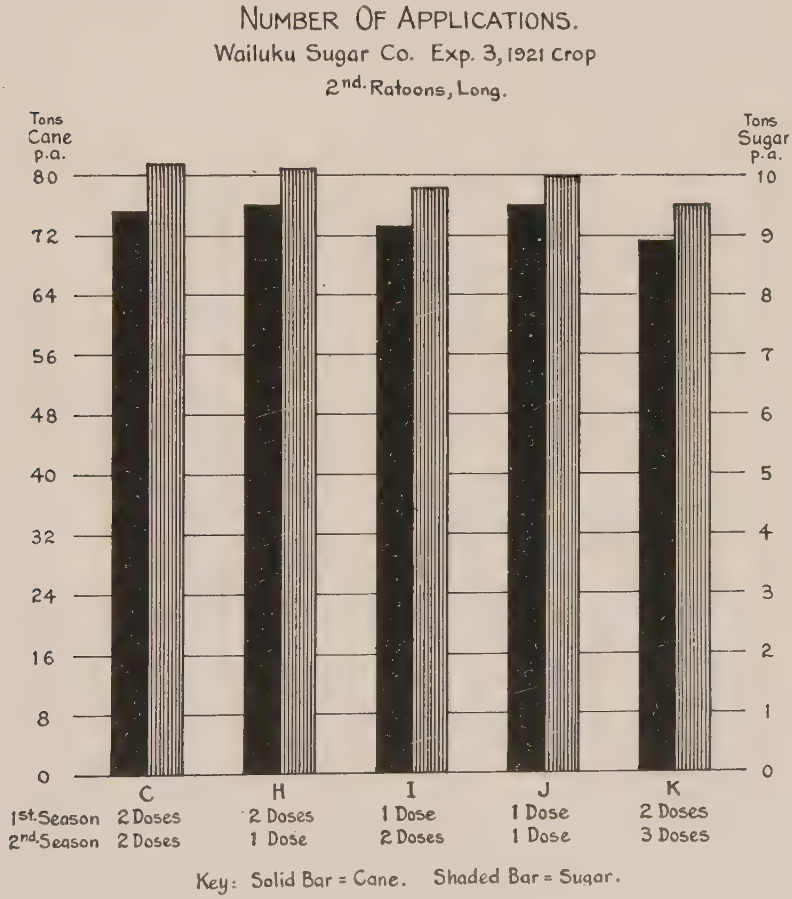
J. A. V.

The Number of Doses in Which to Apply a Given Amount of Fertilizer.

WAILUKU SUGAR COMPANY, EXPERIMENT NO. 3, 1921 CROP.

This was an experiment to determine the best number of doses in which to apply a given amount of fertilizer.

The cane was Lahaina, second ratoons, long, in an irrigated field. The field was harvested late in March and was 21 months old at the time. All plots received the same amount of fertilizer, one-half of the nitrogen being applied each



season. A total of 200 pounds of nitrogen per acre was used. During the first season B 6, a mixed fertilizer, was applied and nitrate of soda during the second season. The number of doses in which the above fertilizers were used varied from two to five.

The following table gives the amounts and time of application:

POUNDS OF FERTILIZER PER ACRE.

Plots	No. of Plots	Aug., 1919 B 6 *	Nov., 1919 B 6 *	Feb., 1920 Nit. Soda	Apr., 1920 Nit. Soda	June, 1920 Nit. Soda	Total Pounds	
							Nit.	P_2O_5
C	17	455	455	323	322	0	200	55
H	16	455	455	645	0	0	200	55
I	17	910	0	323	322	0	200	55
J	17	910	0	645	0	0	200	55
K	17	455	455	215	215	215	200	55

* B 6 = 11% N., 6% P_2O_5.

The results obtained from the different treatments were as follows:

Plots	No. of Applications	Tons per Acre		
		Cane	Q. R.	Sugar
J	2 Applications......................	76.1	7.61	10.00
H & I	3 "	74.7	7.50	9.96
C	4 "	75.4	7.37	10.21
K	5 "	71.3	7.50	9.51

The results from the use of two, three or four doses of fertilizer vary but little. When the fertilizer was applied in five doses the yields were distinctly lower.

DETAILS OF EXPERIMENT.

Fertilization — Number of Applications.

Object:

To compare the following methods of application:

(1) Four equal doses, two in first and two in second season.
(2) Three doses, two in first, one in second season.
(3) Three doses, one in first, two in second season.
(4) Two doses, one in first, one in second season.
(5) Five doses, two in first, three in second season.

In all cases half of the fertilizer is applied each season.

Location:

Wailuku Sugar Company, Field No. 98.

Layout:

Number of plots = 84.

Size of plots = 1/16 acre, consisting of 8 lines, each 4.5′ wide and 75.5′ long. One blank line left between each plot. This area comprises former Wailuku experiments Nos. 3 and 4.

Number Of Applications

Wailuku Sugar Co. Exp. 3, 1921 Crop

2nd. Ratoons, Long.

8' Path — 8' Path — 8' Path — 8' Path

		Level	Ditch		
78 C 83.92	77 K 78.56	76 J 89.04	75 I 71.44	74 H 94.08	73 C 92.96
84 K 80.72	83 J 76.08	82 I 96.00	81 H 58.08	80 C 83.44	79 K 82.72
90 J 80.96	89 I 68.16	88 H 66.88	87 C 54.96	86 K 90.56	85 J 81.52
96 I 67.76	95 H 59.92	94 C 61.76	93 K 58.08	92 J 77.28	91 I 84.40
102 H 75.92	101 C 58.08	100 K 53.76	99 J 61.28	98 I 73.60	97 H 91.44
108 C 83.84	107 K 76.32	106 J 74.24	105 I 61.84	104 H 83.52	103 C 81.20
		Level	Ditch		
114 K 87.92	113 J 91.12	112 I 88.88	111 H 87.04	110 C 95.76	109 K 68.88
120 J 95.12	119 I 86.80	118 H 91.52	117 C 78.48	116 K 76.80	115 J 82.64
126 I 93.04	125 H 66.48	124 C 89.52	123 K 71.36	122 J 72.88	121 I 91.92
132 H 91.36	131 C 70.88	130 K 86.88	129 J 68.72	128 I 75.20	127 H 74.16
138 C 92.24	137 K 79.28	136 J 78.52	135 I 61.04	134 H 72.48	133 C 65.10
144 K 81.28	143 J 74.40	142 I 75.28	141 H 62.32	140 C 66.56	139 K 53.52
150 J 83.84	149 I 75.44	148 H 77.92	147 C 52.32	146 K 40.48	145 J 49.92
156 I 74.72	155 H 64.64	154 C 69.84	153 K 45.60	152 J 47.36	151 I 53.68
		Level	Ditch		

Summary of Results

Plots	No. of Plots	Treatment		Tons Per Acre		
		1st. Season	2nd. Season	Cane	Q. R.	Sugar
C	17	2 Doses	2 Doses	75.35	7.37	10.21
H	16	2 "	1 Dose	76.11	7.52	10.12
I	17	1 Dose	2 Doses	73.26	7.47	9.80
J	17	1 "	1 Dose	76.11	7.61	10.00
K	17	2 Doses	3 Doses	71.34	7.50	9.51

Note- $\frac{1}{2}$ Nitrogen 1st. season. $\frac{1}{2}$ 2nd. season.

Plan:

FERTILIZATION*—POUNDS OF NITROGEN PER ACRE.

Plots	No. of Plots	1st Season		2nd Season		
		Sept. 1, 1919	Nov. 1, 1919	Feb. 15, 1920	April 15, 1920	June 15, 1920
C	17	50	50	50	50	0
H	16	50	50	100	0	0
I	17	100	0	50	50	0
J	17	100	0	100	0	0
K	17	50	50	33½	33⅓	33⅓

* Fertilizer: First season, B 6 = 11% N., 6% P_2O_5. Second season, Nitrate of soda = 15.5% N.

Experiment planned by J. A. Verret.
Experiment laid out by L. T. Lyman.

J. A. V.

Fertilizer—Time and Number of Applications.

Waipio Experiment B. 1921 Crop.

The experimental cane was H 109, first ratoons, long, and was twenty-four months old when harvested, at which time it had not been irrigated for one hundred days. The cane was harvested June 29 to July 13.

All plots received nitrate of soda at the rate of 1613 pounds per acre, equivalent to 250 pounds of nitrogen per acre. No other form of fertilizer was used.

The fertilizations received by the different plots are given in the following table:

Plots	No. of Plots	Pounds Nitrate of Soda per Acre				Total Nitrogen
		Aug., 1919	Nov., 1919	Feb., 1920	May, 1920	
A	12	807	0	806	0	250 lbs.
B	12	807	0	403	403	"
C	12	403	403	403	404	"
D	12	403	403	807	0	"
E	12	403	0	1210	0	"
F	12	1210	0	403	0	"

The results obtained are given as follows:

TABLE I—NUMBER OF APPLICATIONS.

Plots	Number of Applications	Tons per Acre		
		Cane	Q. R.	Sugar
A, E, F	2	110.6	7.70	14.36
B, D	3	111.6	7.67	14.56
C	4	110.5	7.66	14.42

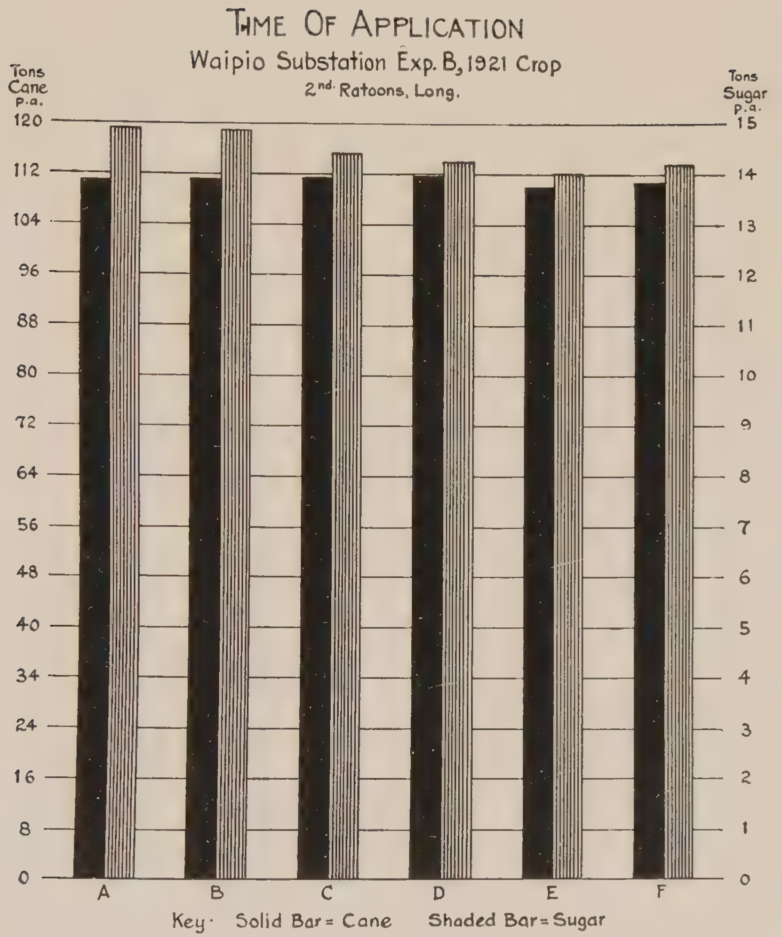


TABLE II — PROPORTION OF FERTILIZER TO APPLY EACH SEASON.

Plots	Methods of Application		Tons per Acre		
	First Season	Second Season	Cane	Q. R.	Sugar
A, B, C, D	½	½	111.2	7.61	14.61
E	¼	¾	110.0	7.85	14.01
F	¾	¼	110.6	7.80	14.17

The yields given in Table I show a most remarkable uniformity. Were all the plots to receive identical treatment closer checks could not be expected. It made no difference at all whether the fertilizer was applied in two, three, or four doses.

The results given in Table II also show close agreement for the different treatments, but there would seem to be a slight tendency in favor of dividing the fertilizer equally between the two seasons.

In both of the tables given above there is much more variation in the yields of sugar than in that of the cane. We feel that these greater variations in the

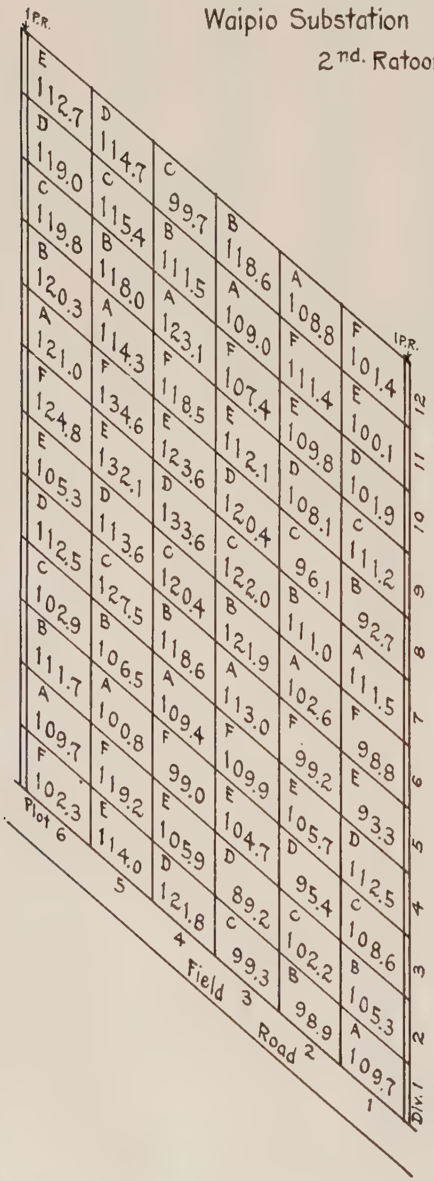
yields of sugar are due more to difficulties in sampling and in varying intervals of time between burning and sampling at the mill, than to the various fertilizer treatments.

The average composition of the juices from all the plots was 20.1 brix, 17.48 polarization, and 87 purity. The yields reported from all Waipio experiments are reduced sixteen per cent to account for ditches and water courses, so that the figures given will be directly comparable with those of other irrigated plantations.

Time Of Application

Waipio Substation Exp. B, 1921 Crop

2nd. Ratoons, Long.



Summary of Results

Plots	No. of Plots	Treatment			Tons Per Acre		
		1st. Season	2nd. Season	Nitrogen	Cane	Q.R.	Sugar
A	12	1/2	1/2	250*	111.1	7.45	14.91
B	12	1/2	1/4 1/4	250*	111.3	7.47	14.89
C	12	1/4 1/4	1/4 1/4	250*	111.5	7.66	14.42
D	12	1/4 1/4	1/2	250*	111.9	7.86	14.24
E	12	1/4	3/4	250*	110.0	7.85	14.01
F	12	3/4	1/4	250*	110.6	7.80	14.17

DETAILS OF EXPERIMENT.

Object:

1. To determine the proportion of fertilizer to apply each season.
2. To determine the most profitable number of doses.

Location:

Waipio Substation — Section 3, Experiment B.

Crop:

H 109, first ratoons, long.

Layout:

Number of plots = 78.
Size of each plot = 1/30 acre.
Number rows per plot = 8.

Plan:

Fertilizer to be applied each season as follows (reported in pounds nitrogen per acre):

Plot	No. of Plots	First Season		Second Season		Total Lbs. Nitrogen
		Aug., '19	Oct., '19	Feb., '20	May, '20	
A	12	125	0	125	0	250
B	12	125	0	62.5	62.5	250
C	12	62.5	62.5	62.5	62.5	250
D	12	62.5	62.5	125	0	250
E	12	62.5	0	187.5	0	250
F	12	187.5	0	62.5	0	250

Nitrogen to be obtained from Nitrate of Soda 15.5% N.

Experiment planned by J. A. Verret.
Experiment laid out by R. M. Allen.
Experiment harvested by A. Paris.

J. A. V.

Improvement of Rice by Selection and Hybridization in Java.*

The methods of selection employed at Buitenzorg on the same lines as those employed at Svalof for the cereals in Northern Europe are based on the following facts, in accordance with botanical and genetical theories held by a large number of specialists:

(1) The cultivated varieties of rice (these should not be confused with botanical varieties) include a considerable number of fixed strains, similar to those known in the botanical world under the name of "sub-species" or "Jordan species."

(2) Each of these strains differs from the surrounding types of the same

* Wiellard, P., in Bulletin agricole de l'Institut scientifique de Saigon (Year 11, No. 1, pp. 11–15, Saigon, Jan. 1920), as abstracted in International Review of the Science and Practice of Agriculture—Year XI, No. 5, May, 1920.

variety in characters of negligible importance morphologically, but which mean a great deal from the cultural standpoint (e. g.: yield, early maturity, resistance to disease, etc.). These distinctive characters are admittedly entirely transmissible to progeny.

(3) Compared with the habit of several other cereals, self-pollination is the usual habit with rice, and cross-pollination is very rare. This certainly facilitates to a large extent the process of selection, as it permits close spacing, and of several pure lines coming from the same or different varieties, without running the risk of undesirable crosses.

It is easy to see, therefore, that if a cultural variety is selected which shows a combination of good characters (weight of yield, quality of grain, resistance to disease), or which possesses one of these points to a marked extent, it will be sufficient to multiply a pure line to obtain several generations later, a new cultural variety following the natural course, but with the advantage of each individual possessing qualities of a select strain superior in one form or another to the original variety ("population").

The following is a brief survey of the method employed in Java at Tjikenneuth.

The "population" rice is sown in the nursery according to the usual custom, and then pricked out on to an area of about 20 acres, with much care taken to avoid putting more than one plant into each hole. Throughout the growing period, the rice field is watched, and out of the 10,000 or 200,000 plants thus pricked out, about 300 select types are chosen.

The record of the yield of each plant is made separately. In the laboratory, the less interesting ones are eliminated, and about 75 to 80 in all, are conserved. These will form the origin of the pure line selection.

The following year, each of the 75 to 80 lines thus obtained is sown and repricked out, always at equal distances apart, on small plots (4.7 to 7 sq. yds.). Three plots at least are reserved for each line and these are distributed in various quarters of the field, so as to avoid variations due to dissimilarity of soil. In the harvest season, the produce from all the plots is collected at the same time. In this way 75 to 80 crops are obtained, and these are investigated in the laboratory according to the characters it is desirable to retain.

The third year, work is not continued with the 10 to 15 best lines in the second selection, but this time the plots reserved for each line and these are multiplied as far as possible. The crops thereby obtained serve as a base for the definite choice of the type, or types, which will advantageously take the place of the original "population."

At Java, up to the present time, a dozen varieties have undergone this method of selection and have furnished twenty pure lines. These lines multiplied over large areas, for the last two or three years in control plots, have shown homogeneity and fixed characters as expected. With regard to the yield, there was an average increase of 20%.

It is noticeable, as predicted, that the results obtained showed a distinct improvement to the original and less homogenous population.

The Tjikenneuh Station is assisted in plant breeding work by the co-operation of the "Jardins de semences" directed by M. Van Der Stok, and the work

extends over the center and east of Java and to demonstration fields at the local agricultural schools. It is reasonable, therefore, to hope that the results, already distinctly advantageous, will be accentuated and confirmed in the near future.

The author gives a brief survey of the hybridization experiments made at Tjikenneuth.

Artificial pollination of rice is a somewhat difficult operation, which was for a long time considered impossible.

M. Van Der Stok, who was the first to succeed, has, however, never obtained more than a very minor degree of success. The local varieties, crossed seven years before and with progeny followed with great care up to the present time, are "Skriviman Koti" and "Carolina." The first is a plant of very considerable vigor, leaves dark green, form erect. The yield is high, but unfortunately the grain is of an inferior quality. The second variety, on the contrary, shows lack of vigor, the leaves are large, light green and drooping, but it makes up for this by producing grain, although in poor quantities, of the biggest and best quality obtainable in Java and perhaps even in the whole world. The flowering period is three weeks earlier than that of Skriviman Koti.

Hybrids are selected in each generation. F, under the author's observation, gave more than 200 hybrids cultivated on plots of an average area of 7 sq. yd., and which showed a combination of characters of the two parents. In several cases "transgression" was noted.

Certain hybrids flowered eight days earlier than Carolina (the variety which matures the quicker of the two parents). Others gave larger grain than Carolina. These facts are sufficiently encouraging to raise hopes, and the confirmation of the results obtained at Tjikenneuth will open up an efficient means of action to rice breeders for the improvement of local varieties, by crossing with superior imported varieties.

The Dwarf Coconut in the Federated Malay States.*

The increasing rise in the price of copra having given renewed activity to coconut planting in this country, it is important that some facts of this interesting variety of coconut should be put on record.

Description: The dwarf coconut, known in this country as "nyiur gading," is remarkable for its early fruiting, palms only 10 feet high bearing abundant fruits touching the ground. The young palm grown under good conditions starts to flower in its third year and produces ripe fruit in about nine months from the appearance of the flower spike. The initial flower spikes contain only male flowers, but other spikes occurring in rapid succession, are larger and bear an increasing number of female flowers, one spike from a six-year-old tree bearing 200 young female flowers, whilst trusses of fruit from similar trees have been found with as many as 55 ripe nuts.

* Handover, W. P., in The Agricultural Bulletin of the Federated Malay States, Vol. VIII, No. 5, p. 295–297. Kuala Lumpur, Sept.-Oct. 1919.

The dwarf coconut is generally of a bright yellow color. There is besides a distinct brick-red variety, also a green variety and a number of intermediate colors which might be ranged as ivory yellow "gading," golden yellow, orange brick-red, green bronze, and deep green. The flower spikes, leaf bases, and leaf ribs correspond in color with the fruit, giving the compact trees a very handsome appearance. Again there are semi-tall trees of these different colors, which are later coming into bearing, having slightly larger nuts, and are less prolific than the true dwarf.

The dwarf yellow strain appears as the most prolific, whilst the other varieties vary proportionately in their productiveness and also in the shape and size of the nut, and are evidently the outcome of cross-fertilization from original types or "mutants" (1).

The different varieties are distinguished amongst the Malays and Javanese under particular names, such as "nyur," "(klapa)gading," "k. merah, (or sajah)," "k. kapak," "k. pisang," "k. puyok," "k. hahi," "sepang," and "k. nipah."

A full-grown leaf of the "nyiur gading" measures only 12 feet from base to tip, whilst the ripe nut measures 22½ inches by 24, and the stem 24 inches in girth; the nut has an average amount of fiber, a thin shell, and proportionately with the big nut, a good thickness of white kernel.

This "meat" is said by the Malays to be richer in oil and sweeter in taste than that of the big coconut, and it is therefore very popular with them for domestic purposes.

History: In spite of diligent inquiry, it has not been possible for the author to find out the definite origin of this dwarf nut, but it seems first to have occurred as a "sport" or "mutant," probably in Java. Trees, thirty years old or so, occur in different parts of the peninsula and many of these still bear abundantly.

In 1912, 500 acres were planted with these dwarf nuts at Sungei Nipah Estate on the coast between Port Dickson and Sepang Point, and this is probably the only estate of dwarf coconuts in the world.

Growth: Like all coconuts, this dwarf form appears to be exceedingly hardy, growing well either in white clay, red loam, or deep peat; in fact it seems to thrive in any situation where water is abundant, yet not stagnant, though it is evident that well-drained alluvin suits it best.

In such a soil, six-year-old palms have been counted with 234 nuts (excluding ovules), and the trees average 80 nuts a year.

Crop: In the first year of production at Sungei Nipah the crop over 225 acres was 102,000 nuts, whilst the second year it was 574,000 nuts, and the third year it will probably be nearly a million; from which the author considers an average yield for dwarf nuts may be estimated as follows:

At the end of 4th year (1st yielding year).......	10 nuts per tree	
At the end of 5th year (2d yielding year).......	30 nuts per tree	
At the end of 6th year (3d yielding year).......	60 nuts per tree	
At the end of 7th year (4th yielding year).......	80 nuts per tree	
At the end of 8th year (5th yielding year).......	100 nuts per tree	
At the end of 9th year (6th yielding year).......	120 nuts per tree	(In full bearing)

These estimates, in face of yields from individual trees, will appear con-

servative, but there are many points which have to be considered when dealing with average yields, and no doubt under ideal conditions a much higher average could be obtained.

In making copra, it has been found that the nut from a young tree is smaller than that forming later, and its kernel likewise thinner, whilst of course, on heavy yileding trees the nuts are a little below the average in size, but 500 nuts to a pikul (1) of copra is a general average, which would be decreased somewhat later as more even nuts with thicker "meat" are obtained. With the leaf length only 12 feet, it was found convenient to plant the palms 24 ft. x 20 ft., which gave 90 to the acre, a number nearly double to that required when planting big palms.

It is evident, therefore, that with this planting we should get, say, in the fifth year of planting 90×30 nuts $= 2700$ nuts per acre $= 27 \div 5 = 5\ 2/5$ pikuls copra per acre. Likewise, in the ninth year $90 \times 120 = 10{,}800$ nuts per acre $= 108 \div 5 = 21\ 3/5$ pikuls copra per acre. Comparing this with the big coconut, which does not produce till after its fifth year, it might be estimated as giving in its ninth year 45 trees at 40 nuts $= 1800$ nuts per acre $= 1800 \div 220 = 8$ pikuls of copra per acre. With the dwarf trees there is the great advantage of easy and rapid picking and inspection for beetles and other pests, though of course in manufacture almost 2½ times the number of nuts per pikul of copra handled, but this is not of so great a consequence when working with newly devised methods and machinery, dealing with large quantities.

The profit per acre from five-year-old dwarf coconuts today can even stand comparison with that of rubber, and the man who is planting today has to consider markets five years ahead, and might do worse than place confidence in the dwarf coconuts.

SUGAR PRICES FOR THE MONTH

Ended August 15, 1921.

		96° Centrifugals		Beets	
		Per Lb.	Per Ton.	Per. Lb.	Per Ton.
	(July 16, 1921)	4.50c	$ 90.00	No quotation.	
[1]	" 18	4.64875	92.975		
[2]	" 19	4.555	91.10		
[3]	" 20	4.61	92.20		
[4]	" 25	4.7425	94.85		
	" 26	4.61	92.20		
[5]	Aug. 1	4.86	97.20		
[6]	" 15	4.8125	96.25		

[1] This price consists of a sale of Cubas 4.61 and a sale of San Domingo at 4.6875. San Domingo sale is export.

[2] This price consists of sale of Cubas 4.61 and Porto Ricos 4.50.

[3] Cubas.

[4] This quotation covers sale of Cubas 4.61 and sale of full duties 4.875. Latter sale export.

[5] Both Porto Ricos and Cubas sold same price. Fair volume.

[6] One sale San Domingo 4.875 export. One distressed lot Porto Rico 4.75.